AD-A210 534 LASER TECHNOLOGIES IN INDUSTRY(U) PORTO UNIV (PORTUGAL) 1/4
JUN 88 R/D-5969-EE-02 DAJA45-88-M-0126

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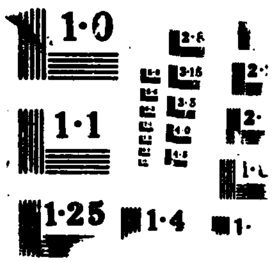
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INVENTORY

LASER Technologies IN INDUSTRY

DOCUMENT IDENTIFICATION

JUNE 1988

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AD-A210 534

LASER TECHNOLOGIES IN INDUSTRY

6-7-8 June 1988 ·· —— ·· PORTO ·· —— ·· PORTUGAL

DAJA45-88-M-0126

1 - Organizing

LASER technologies are rapidly expanding with a perculation in every major field of science, technology, medicine and art.

LASER TECHNOLOGIES in INDUSTRY was designed to provide an assessment of and the dissemination of information on the following aspects of LASER technologies for industry: metrology, detection, machine and process control, nondestructive testing for quality improvement; processing of metallic and non metallic materials for increasing the productivity of small manufacturing enterprises; applications to robotics and automation (equipment and systems, cost-benefit analysis) technology transfer mechanisms, European programs for technological development.

The impact areas intended were:

- technological innovation
- rationalized usage of traditional and new materials
- creation of new design and manufacturing methods
- methods for the fabrication of new types of products
- productivity increases
- quality improvements
- greater competitiveness for European industry in European and world markets with resulting benefits in terms of expanded markets created by new products, improved competitive positions through better quality products, introduction of new manufacturing technologies having greater commercial impact, and introduction of innovative manufacturing technologies facilitating new fabrication methods and the ability to fabricate new types of products.

To ensure that the objectives could be fully achieved a clear strategy was established from the beginning.

Profuse meeting and discussions were held to define concerted actions.

Results were laid down on a Conference Guide (annexed) that was circulated to Committees Members.

From there in cooperation with the Organizing Committees the establishment of the programme started taking shape bearing in mind the concept of an European Dimension.

Indeed the European Dimension of the Conference was reached by:

- involving in the preparation of the conference relevant organizations from many Member States
- participation of invited and contributing speakers from all Member States
- giving a Community-wide view of the present state-of-the-art of LASER Technologies and future trends with reviews, specialized assessment studies presentations and two complementary specialized workshops
- publishing the results with distribution to all participants of collected abstracts and an expected 1,300 pages proceedings due in two months.

LASER TECHNOLOGIES IN INDUSTRY

6-7-8 June 1988 — PORTO — PORTUGAL

CONFERENCE GUIDE

Important Dates:

Call for papers	- July/September 1987
Abstracts due	- 15 November 1987
Final manuscript	- 15 February 1988
Invited Papers Final form due	- 15 January 1988
Advance programme	- 15 December 1987

IMPORTANT INFORMATION

PLEASE RETAIN THIS FILE

CONCEPT

LASER TECHNOLOGIES in INDUSTRY is a international conference supported by the Commission of the European Communities (programme for the transnational development of the supporting infrastructure for innovation and technology transfer).

The objectives of the conference are the valorization, assessment of and the dessemination of information as well as promotion of all the aspects of Laser Technologies for industry.

The following major topics related to Laser Technologies in Industry have been identified:

- General Overview
- Metrology, detection, machine and process control, non-destructive testing for quality improvement
- Processing of metallic and non-metallic materials for increasing the productivity
- Applications to robotics and automation (equipment and systems, cost-benefit analyses)
- Technology Transfer Mechanisms and European Programs for Technological Development
- Further Topics

The intended impact areas comprehend:

- technological innovation
- rationalized usage of traditional and new materials
- the creation of new design and manufacturing methods
- methods for the fabrication of new types of products
- productivity increase
- quality improvement
- greater competitiveness for Laser using industry in World Market;

and the demonstration of resulting benefits in terms of:

- expanded markets created by new products
- improved competitive positions through continuing improved quality products
- introduction of new manufacturing technologies having major commercial impact
- introduction of innovative manufacturing technologies facilitating new fabrication methods and capabilities to produce new families of products

ORGANIZING PROCEDURE

The Conference is being organized according to the following pattern:

- Openning Welcome
  Key Address

- 3 Parallel Sessions

  - Metrology
  - Materials Processing
  - Robotics and Automation

  including GENERAL OVERVIEW (plenary sessions?)
  Further Topics

- A POSTER session could be included

- An Exbition is being considered:

  i) Books and scientific literature
  ii) Equipment

- Social programme will be included

Programme co-ordinators will organize the different parts of the programme:

GR - GENERAL OVERVIEW

MT - METROLOGY

MP - MATERIALS PROCESSING

RA - ROBOTICS and AUTOMATION

FT - FURTHER TOPICS

It is expected that two programme coordinators per topics MT, MP, RA will provide invited papers reviewing the topics. Each of the programme co-ordinators will select another invited speaker to complement the coverage of the said topic.

From the topics GR and FT it is also expected to assemble four other invited papers.

The Conference will then have an extensive coverage via invited papers:

GENERAL OVERVIEW
- invited paper (authored by programme coordinator)
- invited paper (authored by invited speaker by invited coordinator)

METROLOGY
- invited paper, invited paper: authored by the two programme coordinators
- invited paper, invited paper: authored by invited speakers by programme coordinators

MATERIALS PROCESSING
- invited paper, invited paper: authored by the two programme coordinators
- invited paper, invited paper: authored by invited speakers by programme coordinators

ROBOTICS and AUTOMATION
- invited paper, invited paper: authored by the two programme coordinators
- invited paper, invited paper: authored by invited speakers by programme coordinators

FURTHER TOPICS
- invited paper (authored by programme coordinator)
- invited paper (authored by invited speaker by programme coordinator)

These sixteen papers together with Key note paper will form the FIRST volume of the proceedings TO BE AVAILABLE at the CONFERENCE SITE at the registration desk.

Average size of the papers is expected to be 20 pages.

Contribution papers will be assemble in the SECOND volume of proceedings and if possible should be available at the CONFERENCE at the registration desk.

SPIE will publish the proceedings from camera-ready manuscript supplied by authors.

The programme coordinators would assemble the papers for the second volume.

The strategy for obtaining the papers is via:

i) personal contacts leading to invited contributions
ii) selection of contributing papers in response to call for papers

The programme coordinators will be the co-editors of respective sessions.

The members of the various committees are expected to help in coordination with programme coordinators the full procedure.

Financial support is to be given to programme coordinators and their invited speakers (selected from countries withing the EEC).

Finantial funding will only be made available after due reception of manuscript in camera-ready form.

COMMITTEES

- Organizing Committee
- Programme Coordinators
- International Advisory Committee
- Honors Committee

ASSIGNED FUNCTIONS

ORGANIZING COMMITTEE

The organizing and full coordination of the event.

In running the conference they are asked to assist in:

- Conference promotion
- Organizing the programme
- Contributing to a raising of financial funding
- Contributing to the speedy and fine publication
- Helping in every possible way

PROGRAMME COORDINATORS

- Contributing with an invited paper presenting a review on the concerned area
- Selecting an invited speaker for a review paper covering complementary aspects
- Selecting invited contributions
- Selecting the submitted papers
- Proposing the sessions structure

A text two paragraph long is requested for inclusion on the CALL for PAPERS.

Conference topics to be featured and emphasized are also requested.

Copies of manuscript from speaker / authors are sent for manuscript suitability evaluation for presentation and proceedings publication.

Formal refereeing is not absolutely necessary but overall quality must be guaranteed.

As co-editors of the proceedings programme coordinators will be asked to encourage authors to submit manuscripts by the manuscript dead line and to write an introduction to corresponding part of the volumes. This introduction will summairize the concerned contributions in terms of aims and relevance of technologies.

MAIN SUGGESTIONS

- Do not depend on the CALL for PAPERS to generate contributions to the programme
- Identify as soon as possible speakers / authors and session chairmen
- Obtain a firm commitment from every speaker / author to prepare a manuscript as well as a presentation. Do not waive the manuscript requirement
- Urge all speakers / authors to obtain all necessary clearances immediately
- Do not extend deadlines without prior approval from organizing committee
- Advise the organizing committee immediately of any speakers added/deleted from the meeting
- Please do not offer financial support to any participants without approval from the organizing committee
- Finantial funding will only be made available after due reception of manuscript in camera-ready form.

SESSION PLANNING SHEET

Please complete separate form for each session

Session Title:____

a.m.______

Session#_____ p.m.______ Title:______________________________

Session Chairman (affiliation and address):

Phone:____________________

Titles of papers (list in order of presentation)	Authors/Co-authors (affiliation, address, phone)

SUMMARY OF PROCEDURE

MANUSCRIPTS	- a manuscript in camara-ready form is REQUIRED of every author who presents a paper
DEADLINES	- the deadlines shown are firm in that failure to meet them results in the inability to communicate programme information in a timely manner, missed press dates, and a worst, publication of inaccurate or incomplete information
AUTHOR REGISTRATION FEES	- authors are required to pay a reduce registration fee
FINALCIAL SUPPORT	- requests should be forwarded to the organizing committee. Registration fees are waived for the programme coordinators, and further requests for fee waivers will be dealt with on an individual basis
WITHDRAWAL	- it is widely considered unprofessional the withdrawall of a paper from a conference after it has been widely advertised to the scientific and technical community
CLEARANCES	- it is the authors responsability to obtain all clearances, whether governement, military or company, and to assure their completeness, including allowance for publication of the papers title and authors names and affiliations in the Advance Programme, as well as publication of the paper itself in the Conference Proceeding volumes

- International Advisory Committee

WORKING DOCUMENT
PROVISIONAL

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- Robotization & Automation -

-

- Further Topics -

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Honors Committee

GENERAL INFORMATION

OFFICIAL LANGUAGES

English and Portuguese are the official languages of the conference.
Simultaneous translation will be available.
Please contact the organizing committee for any other arrangement.

ADVANCE PROGRAMME

The Advance Programme will be widely distributed.

It provides details of the programme content and speakers/authors as well as proceedings.

The Advance Programme must then be complete, accurate and comprehensive.

Help to procedue the Advance Programme by:

- ensuring that speakers/authors are committee to provide a camera-ready manuscript for the conference proceedings

- submit to the organizing committee in time a programme plan for respective sessions

- programme of planned sessions should specify:

  - paper titles, authors filliations, addresses
  - sessions subtitles if any and sessions chairmen

The paper titles should be given in order of presentation.

Based on sessions programme plan SPIE will attribute a Code Number to each paper and send to the first author an Authors Kit.

- Length of Presentation

  - Invited papers could be allowed 50 minutes presentation followed by 10 minutes questions/discutions

  - Contribution papers will have in average 15 to 20 minutes each presentation plus a 5 minutes questions/discussions (depending on the number of papers in each session)

Typical day conference schedule

8.30	- start session (openning, keynote paper)
10.00 - 10.30 15.00 - 15.30	- coffee breake
12.00 - 13.30	- Lunch break
17.00	- end of session

Financial Support for Speakers

Financial support should not be offered unless prior agreement with the organizing committee was reached.
Requests for registration fee waivers will be consider on an individual basis.

FINAL PROGRAMME

The final programme will be distributed to all conference attendees at the conference site. It is a revised version of advance programme containing last-minute additions or deletions and author or title corrections

PROCEEDINGS of the CONFERENCE

The Conference proceedings will comprehend two volumes. First volume to be published before the Conference date with invited papers

PROGRAMME SUGGESTIONS

Although extensive distribution of information, posters, call for papers and advertizing in scientific Jornals is planned, the experience shows that the efficiency of this method is low (10%). Soliciting speakers as soon as possible by personal contact has proved to provide better results.

REGISTRATION FEES

Registration fee ———————————— 25 000$00 (*) (Escudos)

Comprehends

- Coffee-breaks
- Programme
- Closing dinner
- Wellcome party
- Social events

Registration fee for supporting societies menbers and advanced registration before 1st April 1988 ——— 20 000$00

Students ———————————— 9 000$00

Includes

- Coffee-breaks
- Programme
- Social events

Speakers/authors who attend the conference will be entitle reduce-rate registration fee

(*) (1 USA$ = 143$00 Escudos)

ACCOMMODATION INFORMATION

A few rooms were possible to be reserved at a superb 5 stars HOTEL

HOTEL PORTO ATLANTICO

Special rates: single ———— 5 800$00
double ———— 6 800$00

Very special offer: Breakfast + main meal + double —— 10 000$00
single —— 7 200$00

Further Hotels:

Special rates for Conference participants

	Classf.	Single	Double
HOTEL MERIDIEN	5 stars	10 500$00	11 900$00
HOTEL SHERATON	5 stars	8 400$00	9 600$00
HOTEL BOA-VISTA	4 stars	5 200$00	6 400$00
HOTEL INCA			
HOTEL BOEGA			

Special rates could be extend to members of the family and for extra-conference days.

Please be aware that due to the multiple fairs and other events in Porto, Hotel booking should be done as earlier as possible. Full rate will apply also for late booking.

(1 USA$ = 143$00 Escudos)

ACCOMMODATION INFORMATION for VIPs (very important participants)

We are pleased to annouce that we manage to obtain a very special rate at a superb 5 stars HOTEL to accommodate some of the VIPs (very important participants).
It was also possible to obtain the extension of the spacial rates to family members and for extra-conference days.

Very special rates:

Double room with breakfast, one main meal ———— 10 000$00 (Escudos)

Single room with breakfast, one main meal ———— 7 000$00 (Escudos)

Please be aware that due to the multiple fairs and other events in PORTO, HOTEL booking should be conveniently done as earlier as possible.
The number of room available is limited and therefor we are forced to follow the rule first requested first booked.
Transfer to the conference site and to the airport could be provided.

(1 USA$ = 143$00)

SOCIAL PROGRAMME

To all registred participants

- Wellcome party with projections of a DIAPORAMA about PORTO city
- Typical gastronomic dinner with a parade of old costumes and ancient Jewlery from Alto-Minho (North of Portugal)
- Closing dinner and musical event

Optional

- Dinner and boat trip in the river Douro
- Visit to Porto wine cellars

Accompanying Persons

- Several tours will be organized primarily meant for the accompaning persons

PRE/POST Congress tours

- Selected tours will be offered to those who would like to enjoy and discover the country
- The official TRAVEL AGENT could also deal with your most ambitious to the most exotic wishes. Please indicate what you will be looking for while in Portugal (including Madeira and Azores)

CALENDER

Call for papers	-	July – September 1987
Abstracts due	-	15 November 1987
Notification of Acceptance	-	15 December 1987
Final manuscript	-	15 February 1988
Invited papers Final Form	-	15 January 1988
Advance Programme	-	15 December 1987
Conference Programme	-	31 Mars 1987

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- Session Chairmen

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Oporto

Oporto gave its name not only to the world-renowned wine, but to the country of which it is the second largest city. Situated at the mouth of the great river Douro, the town of Cale and its port on the opposite bank prospered under the Romans as a military and commercial centre "Portus Cale". It remained a stronghold of Christianity during the years of the barbarian and Moorish invasions and the region between the Minho and the Douro was known as Portucale. This region formed part of the dowry of the Princess Dona Teresa when she married Henri of Burgundy in 1095. It was under their son that the country gained its freedom and independence and took its name from that region of Portucale.

Oporto–the name means, simply, the port–is essentially a working city whose inhabitants are proud of their industrious reputation. "Coimbra sings, Braga prays, Lisbon shows off and Porto works" is how an old saying sums up the characteristics of leading Portuguese cities. It is one of those places that does not impress at first sight, but keeps its real attractions hidden away from the casual visitor. However, if you are willing to spend time and effort, Oporto can be a rewarding city, and one with great charm.

Henry the Navigator was Oporto's most famous son, planning his expeditions to North Africa in the city. There is evidence, too, that the family of the Spanish painter Velasquez came originally from Oporto, his grandparents emigrating from there to Andalusia.

It was in 1703 that England and Portugal completed a trading agreement which brought wealth and status to Oporto, ensuring as it did that the region's wine would find a market in Britain and elsewhere, and introducing a British "colony" into Oporto. (More about Port wine and special "wine tours" will be found on pages 21 and 91/93.)

The most popular "image" of the city is of its three famous bridges and of the characteristic craft, known as "barcos rabelos" which ply the river beneath them with their cargoes of wine. Truth to tell, the old craft are now museum pieces, but the bridges are as distinctive as they ever were. The oldest is the Dona Maria Pia Bridge, opened in 1877 and the work of the famous engineer Gerard Eiffel. This railway bridge was followed in 1886 by a two-tier road bridge, based extensively on Eiffel's design. In 1963 the Arrábida bridge was constructed. Its 270-metre span of reinforced concrete forms the largest arch in the world made of that material.

Although the "Ribeira", the riverside area, is the oldest part of the city the best way to begin an exploration of Oporto is to make for the Sé (Cathedral) at the Terreiro da Sé. Before exploring the building itself, look over the stone balcony in front of it at the view of the river and the town, spread out below. This will give you an idea of how Oporto grew from its simple beginnings, how modern buildings have been placed in relation to the old quarters.

Built in the 12th and 13th centuries, the Cathedral, like the city, was "improved" and expanded until about the 18th century. Its twin towers, and its nave are, in the main, original, though the cloister, with tiles depicting events from the Song of Solomon was added in the 14th century and the Chapel of St. Vincent built towards the end of the 16th century. On the Cathedral Square, the 18th century Archbishop's Palace, now used as public offices, is worth your attention, and also nearby is the Casa Museu de Guerra Junqueiro, the famous Portuguese poet who lived between 1850 and 1923. The house/museum contains his art collection and other personal possessions.

Among other sights to be seen in Oporto is the Church of Santa Clara which was completed in 1416, but whose interior was transformed during the 17th century by the addition of gilt carved work which completely covers the altars, walls and chancel. The Carmo Church, too, has an impressive 18th century Baroque facade and much gilt carved work inside.

Closer to the river is the 19th century Palácio da Bolsa which today houses the Stock Exchange. It should be visited for sight of its Arab Hall, which is oval and divided into two floors with glassed-in arcades and a wealth of colour. Of Oporto's museums, the Soares dos Reis National Museum in the Carrancas Palace (once a residence of the Portuguese Royal Family) contains fine examples of the decorative arts–porcelain, glassware and Portuguese faience, as well as paintings from the 16th century to the modern school. And the Museum of Ethnography and History presents the arts and culture of the region, as well as its handicrafts and other aspects of country lifestyles. A reconstruction of a wine cellar and a linen-making apparatus are among the exhibits, along with costumes and ship models and coins and artifacts from Roman times. Oporto itself is of tremendous interest, especially in the area of narrow streets where worn flights of steps carry you from one level to another beside the river.

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1000 LISBOA - PORTUGAL

PORTUGAL

In the southwestern corner of Europe, situated between the Atlantic and the Mediterranean, PORTUGAL has a pleasant and mild climate, where the sun is always shining. A fascinating variety of landscapes, arising from many micro-climates which PORTUGAL enjoys. The discovery, in a few miles, of profoundly different regions. The blue of the sea sparkling in the sun. Mountain tops covered with snow. Beaches of soft, golden sand. The purple of the vineyards on the slopes. Verdant plains. Brooks purling among flowers. PORTUGAL is thus a country of colourful contrasts, where the human hand has added picturesque stone coloured villages. Immaculately white houses. Colourful costumes that continue centuries old traditions.

Peopled from time immemorial PORTUGAL is a country with over ,|it centuries of history. Her people are the descendants of many cultures: Celts, Iberians, Phoenicians, Carthaginians, Greeks, Romans, Goths and Arabs, to mention those who left the deepest mark on the Iberian Peninsula. From north to south, in cities, towns and villages, one can find reminders of the past. Castles perched on crags. The stone filigree of cathedrals. The sumptuousness of carved, gilded wood. The classic elegance of palaces. The surprise of a trip through time upon entering a town surrounded by Medieval walls. These are some of the gems in the treasure that PORTUGAL offers art lovers. The folklore and its variety of regional costumes with their colourful traditions, and handicrafts, where the art of the people expresses itself in every corner of the country, constitute a living reminder all the cultures of the past.

In PORTUGAL, everything is nearby. The mountains almost tower over the sea. Scented pine-trees unfold the beaches. Valleys follow plains. Cosmopolitan life elbows the quiet of the great outdoors. Genuine hospitality and joy have given the Portuguese the art of welcoming people. Finally, the permanent discovery of the ideal spot for reinvigorating holidays any time of the year.

Climate and temperatures

Portugal has a gentle, mild climate, in which the sun is always present.

There are no great variations in temperature. The winter is not harsh and in summer the temperature is never excessively high. There are regional differences in climate and temperature. The north has an Atlantic climate in which the influence of the Gulf Stream is felt. The centre has a transition climate between the Atlantic and Mediterranean, with hot dry summers and short mild winters. The south is Mediterranean as regards dryness, but without the extremes of heat.

The Azores and Madeira have privileged climatic conditions that make the latter a round-the-year tourist resort that is famous all over the world.

Temperature chart

(Mean temperatures in °C and °F)

LOCALITY	JAN/MAR		APR/JUNE		JULY/SEPT		OCT/DEC		
	AIR	SEA	AIR	SEA	AIR	SEA	AIR	SEA	
Monte Estoril	17.1	14.9	21.8	17.5	26.3	19.5	17.2	16.1	°C
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	°F

	Unidade Unit	1986	1987
DESPESA (cresc. volume) / ***EXPENDITURE*** *(real growth)*			
Consumo privado / *Private consumption*	%	7.0	6.5
Consumo público / *Public consumption*	%	1.0	1.0
F.B.C.F. / *G.F.C.F.*	%	9.5	9.5
Export. de bens e serviços / *Exp. goods and services*	%	6.8	4.0
Import. de bens e serviços / *Imp. goods and services*	%	16.5	10.0
P.I.B.$_{pm}$ / *G.D.P.$_{mp}$*	%	4.3	4.0
CONTAS EXTERNAS / ***EXTERNAL ACCOUNTS***			
Balança de bens e serviços / *Goods and services balance*	10^6 US$	−671	−1 460
Transf. unilaterais privadas / *Private unrequited transfers*	10^6 US$	2 619	2 360
Balança de trans. correntes / *Current account balance*	10^6 US$	1 136	400
Dívida externa / *External debt*	10^6 US$	16 109	14 300*
	% do PIB / % of GDP	65.0	44.8

Fontes: B.P.; BPA; PCEDED(*) / *Sources: Bank of Portugal; BPA. Government: medium term programme(*)*

	Unidade Unit	1986	1987
FINANÇAS PUBLICAS / ***PUBLIC FINANCES***			
Déficit orçamental / *Budget deficit*	% do PIB / % of GDP	8.5	8.9
PREÇOS E SALÁRIOS / ***PRICES AND WAGES***			
Taxa de inflação / *Inflation rate*	%	11.7	8.8
Cresc. dos salários reais* / *Real wages (growth rate)*	%	6.6	4.6
EMPREGO / ***EMPLOYMENT***			
Taxa de desemprego* / *Unemployment rate*	%	8.6	8.4
MOEDA E CRÉDITO (taxa cresc. Dez./Dez.) / ***MONEY AND CREDIT*** *(growth rate Dec./Dec.)*			
Depósitos à Ordem / *Demand deposits*	%	44.8	25.0
Depósitos a Prazo / *Time deposits*	%	11.0	11.0
Crédito / *Credit*			
Total / *Total*	%	13.4	11.1
S.P.A. / *Publ. Ad. Sector*	%	22.6	17.6
Empresas e particulares / *Comp. and priv. individ.*	%	7.9	7.1

PAPERS

KEY - ADDRESS

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- Title:

'nformation provided is based on commitments received up to the time of release and are subject to change without notice

EUROPEAN CONFERENCE on TECHNOLOGY and INNOVATION

Suported by the Commission of the European Communities under the plan for transnational development of the supporting infrastructure for innovation and technology transfer.

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International Conference supported by the Commission of the European Communities

ANNEXES

DRAFT

Key - Address

- JNICT —> Nobel Prize?
  (Lasers a Quarter of a Century?)   Prof. de Maria

- Teodore H. Maiman

- Arthur Leonard Schawlow - Stanford University

- Charles H. Townes - University of California

DRAFT

METROLOGY

Co-ordinators

* J. Ebbeni - Lasers in measurement, inspection and control

* W.P.O. Juptner - holography in Industrial Applications

Invited Speakers

Topics Metrology

- Laser Analysis - surface analysis
- Interferometric Metrology in Industry
- Laser Microscopy
- Laser Metrology in production and quality control
- Deformation and vibration measurements
- Laser Metrology for mixture control combustion and exhaust measurement

Suggestions Metrology

- Prof. T.H. Jeong - Optical Fibers Sensors
- Dr. Amar Choudry - Laser Metrology (x Artificial Inteligence)
- Prof. O. Lokberg - ESPI in Industry
- Dr. B. Fagan - Review and prospects ESPI in Industry
- Dr. L. Baker
- Dr. J. Tyrer - ESPI
- Prof. J. Tsujiushi - Laser Metrology for Industry
- Prof. S.P. Almeida - Laser Metrology // Image Processing
- DIFFRACTO
- Rogers - Optical Fb Sensors
- Dr. Schultz-DuBois - (Photon-correlation)
- Prof. A. Lohmann
- Dr. Juptner
- Prof. B. Culshaw - Opt. Fb. Sensors
- N. Abramson - NDT with Lasers
- H. Rottenkolber - Optics Engin. Measurements
- R. Canticui - Laser Measurement in Civil Engineering

  Swiss Federal Lab. Materials Testing
  Dept. Concrete Structures Dubendorf
Address: Ranbbuhlstrasse 21 B
  CH - 8600 Dubendorf
  Switzerland

- R. Krebser - Holography in Plastic Injection Moulden Measurements

  Nestal - Maschinen AG
  CH - 8750 Nafels
  Switzerland

- V. Bodlaj - Laser Distance and Thickness Measurement

  Research Inst. of Sciences AG
  D - 8000 Munchen 83
Address: Werinherstrass 69
  D - 8000 Munchen 90

- Dr. Martens - Optical Fiber Sensors

  Philips GmbH Forschungslaboratorium Hamburg
  Vogt - Kolln Str.. 30
  D - 2000 Hamburg 54

- Mr. Hesse - Lasers in Measurement, Inspection and Control
  Mr. Preier

  Fraunhofer - Institut fur Physikahsehe Mentecknik Freibourg

- E. Kafka - Laser Tire Measurements

  Tire Design Reseach
  Good Year Infer. Tire Tech. Center
  L - 7550 Colmar - Berg
  Tel (0032) 81 99 / 36 86

- Pramod Rastogi - Laboratory Stress Analysis
  Swiss Federal Inst. Techn.
  CH - 1015 Lausanne, Switzerland

- G.T. Reid , NEL, East Kilbride, Glasgow, G 75 OQU, UK

- J.M. Burch

- Post

- D.W. Robinson

- O. Kafri

- K/A. Stetson

- Dr. Gert von Bally - Holographic Fiber Endoscopy

- P. Smigielski

- A. Ennos

- Molesini

- R. Pryputniewriz

- Reid

- G. Sidall (HP)

- K. Stetson

- Prof. H. Klingberg - Laser metrology in production

  Volkswagen AG
  Forshung - Mepotechnik and quality control
  Postfach
  D - 3180 Wolfsburg 1
  Tel (05361) 92 50 01

- Dr. M.A. Beck - Laser Light geometric measurements

  Volkswagen AG
  Forschung - Meßverfahren / 1783
  D - 3180 Wolfsburg 1
  Tel (05361) 92 51 15

- C.A. Sciammarella, Illinois

- H.J. Tiziani

- C.M. Vest - Holography Industry (Review)

- R. Dandliker - Laser Measurements of Vibration and Deformation

  Institut de Microtechnique
  Breguet 2
  CH - 2000 Neuchatel
  Tel (0041) 38-24 60 00

- A Froehly

- L. Piroda

- Geissler - Laser Tech. for Instrumentation (at CERN)

DRAFT

Mat Processing

Co-ordinators

* Steen	- Laser Material Processing in Industry
* A. Sona	- Industrial Application of Lasers - Past, present and trends

Invited Speakers

- E.W. Kreutz	- Laser Material Processsing Industrial Users

Topics (Material Process.)

- High Power Lasers (Industrial Requests)
- Examiner Laser (Demand & Applications in Industry)
- Laser Micromachining
- Laser Tech. in Manufacturing

- Prof. O. Svelto	- General perspective Lasers uses in Industry
- Prof. Krentz Mazunder	- Laser Mat Process
- Mariano P. Amor	- LCVD
- D.P. Vu	- Lasers in Microelectronics Chips Fabrication
- J. Steffen	- Laser Micromachining

Asulab S.A
CH - 2001 Neuchatel
Switzerland

- H.G. Rosen

Siemens AG
Munich

- Influence of System Parameters on Laser Mat. Processing Perfomances

DRAFT

Robotics & Automatization

Co-ordinators

*

*

Invited Speakers

Topics (robotization & automatization)

- Laser Robotics
  - Inspection
  - Mat. Processing
- Structure Light Methods (H. SchmalfuB)
- Flexible Laser-based Machining Centers

- P. Pizzi - Laser Robotics in Mat. Processing
- Hugenschmit
  SBX
- H.H. SchuBler - Laser Measurements on Coord. Meas Machinis and Robots

DRAFT

General Overview

- R. Main - Laser Application Trends in Industry
- H. Koebner - Application of Lasers in Industry

  Munich
  Kreuzdornweg, 3
  D - 8000 Muchen 90

- H. Caufield - Laser Technologies Potencial for Industry
- Dr. R. Poprawe - Application Areas in Industry and Technical Characteritics of Laser Technology (FAST)

  Fraunhofer - Institute fur Laser technik
  Drosselweg 87, 5100 Aachen

- Mr. Derge - Laser Market and Application Trends in Industry

  Spectra Physics
  Darmstradt

DRAFT

Other Topics

- E. Creutzmann - Laser Printers

  Siemens AG, Munchen
  Joseph - Retzer - Str 19
  D - 8000 Munchen 80

- W. Ulmer - Dieboard Laser Cutting

  LKS Laser Kombinationssysteme
  Kelterstr, 93
  D - 3711 Dettingen - Tec

- K. Hinsch - Lasers in Environment Technology and Protection Monitoring

- J. Wolfrum - Lasers in Chemical and Pharmaceutical Industries

Topics General

- Laser in Printing and Reproduction
- Optical Storage, Optical Computing, Data Processing and Optical Communications - The BOOM !

2 - Organizing Committee

The Organizing Committee was formed with the concourse of European acknowledged experts.

To harmonize methods and line of discussion it was taken as a starting point a harmonize document organized by the Chairman the "CONFERENCE GUIDE" that was distributed to all the appointed members of Committees and and Programme Coordinator.

Intensive contacts among members of the different communities and programme coordinators laid the roots for the programme.

From there the Chairmen took the role of linkage by taking advantage of various occasions of expected availability for contacts to fully discuss Organizing procedures.

To a better (and cheaper) development of the organizing work meetings at the Organizing Committee have been arranged during International/European Conferences so that a broader number of members would attend and expenses could be reduced. Among those the most determinant occasions were:

- The fourth International Symposium on Optical and Optoelectronic Applied Science and Engineering in Hague (March/April 1987) was then chosen to establish the main guidelines of the conference based on a document distributed (Conference Guide). The completion of meeting the members led to complement with visits to Firenze and Milano.
- The Laser Science and Technology meeting in Italy (May 1987) made possible to establish the conference programme strategy and the invitation list of speakers.
- The International Symposium of Technologies for Optoelectronics in Cannes (November 1987) gave opportunity for selection of some contributions and re-examination on conference developments. To complete discussion a visit was paid to Bordeaux, Strasbourg and Firenze.
- The OPTICS-ECOOSA 88, in Birmingham (March 1988) was used to define the final programme of the Conference. This was complete with visits to Belgium and U.K.

The active work of the Organizing Committee in establishing the programme was largely supported by the Programme Coordinators that had subdivided their task in three main areas: Metrology, Material Processing, Further Laser Topics.

An International Advisory Committee provided suggestions and contacts that largely enriched the programme.

The poster session coordinator took the task of all the details and logistics of the two poster sessions.

The exhibition was also a local success as a result of the full involvement of Exhibition Coordinator in cooperation with the Organizing Committee.

3 - Programme

The programme in its final format, Annex I, comprehended 26 invited communications covering the main objectives proposed. This has been complemented with a presentation of 97 contributing papers and 31 posters. These around 160 contributions were selected from around 200 offered contributions.

The speakers came both from Industry and Universities as well as other Institutions (Banks, EEC, Consultants, Institutes, Government Laboratories, Laser Centers, etc.) from a wide range of 30 countries with a significant number of delegates from Members States.

An Opening Session formally open the conference and due to the length of material to be presented in ordinary sessions it was shifted to the afternoon of the 5th of June.

Three plenary sessions opened the working days of the Conference covering in a review form and giving the prospects of the three essential aspects intended as gravitational points of the programme.

Four parallel sessions were used to the presentation of papers, combined with two poster sessions.

Two workshops were organized to cover two different important related fields:

- Lasers in Medicine
- Lasers Technologies in Ocean Sciences

The first workshop was intended to respond to an exigence from the scientific community to take advantage of the presence of experts at the Conference to exchange views, evaluate trends and, some concerted actions by European Countries.

The second workshop intended to assess the degree of development in the use of Laser Technologies in the Ocean Sciences, to establish a scenario of perspectives and areas of interest. This in response to the responsibilities and expected involvement of Europe in the domain and aiming to help to achieve improvements in relation to the advance situation of the field in U.S.A. and JAPAN. The topic is particularly appealing to Portugal as a country with a very large Exclusive Zone. There was also the need to respond to the invitation of SPIE on the joint organization of a Research Institute (Expert Meetings and Review Publication) in the near future.

An exhibition was organized to provide atmosphere and motivation to industrialists. Demonstration of various techniques and instrumentation where enlighten with projection of videos and live experiments at the exhibition.

Simultaneous translation has been provided though far from heavily requested due to the technical and scientific character of the conference where audience is usually familiar with technical English.

A social and cultural programme was also offered with a scheduled part under the organizing committee responsibility and an optional part dealt with by the travel agent.

4 - Advertising

There had been profuse dissemination of conference announcements in several languages throughout the European Community and elsewhere.

Promotion of the Conference was done in the various tangible forms:

- advertising on scientific journals
- dissemination of specially printed material
- news release at conference and other meetings

The Annex IV collects some of the material used:

- Preliminary Announcement (15,000)

- Posters	Large -----------	(2,000)
	Medium ----------	(3,000)
	Small (A3) -----	(10,000)

- Call for papers -------- (40,000) (various languages)

- Programme --------------- (4,000)

Distribution by mail was intensively made by recourse to mailing lists, that included more than 7,000 potential participants. These listing covered also member of professional societies such as: SPIE; OSA; SPF; etc.

Advertising of the conference was also expressly made at various meetings and conferences, in particular:

- ICO - 14 (1987)
- LASER 87 - MUNICH (June 1987)
- LASER CONF. - Athens (June 1987)
- OPTICAL ENG. - Cannes (Dez. 1987)
- ECOOSA' 88 - Birmingham (March 1988)

and other meetings that took place in BRUSSELS, PARIS, LONDON, etc.

5 - Financing

The financial support came essentially from the contract 4B-080, SDJ-D01.

This was complemented by the revenue of registration fees which most of the participants have paid at reduce value.

Institutions sponsoring the Conference provided also some forms of financial support.

At the time of writing this report accountacy is still in progress and not all the bills have been received. Nevertheless it is expected that a sound balance will result.

6 - Outcome

The objectives proposed were fully accomplished.

The programme, Annex I, does show the interest the conference has raised and an extensive coverage of the field beyond originally set guidelines.

Indeed the original programme was completed with two workshops to respond to the vivid interest, of the participants, that took place on the 9th June.

The workshop "Lasers in Medicine" had around 50 participants from different backgrounds (physicians, physicists, Industrialists, etc.).

The workshop addressed the following topics:

- Present scenario of Laser Application in Medicine
- Trends in Laser Application in Medicine
- Programmes and Models of European Cooperation at National and Multinational level in the field of Laser Applications in Medicine

From the workshop material a report is to be included in the proceedings.

The workshop LASERS in OCEAN SCIENCES had an attendance of around 40 delegates. Their objectives were:

- Present scenario of Laser Applications in Ocean Sciences
- Trends in Laser Applications in Ocean Sciences
- Programmes and Models of European and Multicontinental Cooperation in the field of Lasers Applications in Ocean Sciences
- Topics for a Research Institute (Review of state-of-the-art and Trends)
- Portugal's participation in the field of Laser Application in Ocean Sciences

With the workshop results it was expected to respond to the interest expressed by SPIE for the organization of an experts meeting in the topic, and requests from the Association Europeenne des Sciences et Technologies de la Mer that is too interested in the development of this interdisciplinary field. This workshop was equally successful and conclusions will be included in the proceedings.

The degree of success was also evident from the spontaneous offer for the organizing of two meetings: one in Madeira - Portugal, and another in Dubrovnik - Yugoslavia.

The Conference had a larger audience that could originally be anticipated.

The computer records shown a 300 participants registered. Another 100 participants attended just some more specialized sessions and around 50 exhibitors animated the exhibition hall.

These 450 delegates came from an impressive variety of countries:

Argentina ---------- 0,7 %
Austria ------------ 0,3 %
Belgium ------------ 2,4 %
Brazil ------------- 0,3 %
Canada ------------- 1,0 %
China -------------- 0,3 %
Denmark ------------ 1,3 %
Finland ------------ 1,7 %

France	3,7 %
F.R.G.	5,4 %
Greece	0,3 %
India	0,7 %
Italy	4,7 %
Japan	1,3 %
Liechenstein	0,3 %
The Netherlands	2,7 %
Norway	0,7 %
Poland	0,3 %
Portugal	53,6 %
Spain	6,7 %
Sweden	1,0 %
Switzerland	0,3 %
Turkey	0,3 %
U.K.	0,3 %
U.S.A.	2,4 %
Yugoslavia	0,7 %

Participants, in general, felt compensated for their involvement and enjoy the atmosphere. Ample opportunity was given to networking so that reasonable hope exists towards the development from contacts into progressive cooperation and eventually dissemination of the technologies discussed.

The scientific and technological exchange as the materializing of industrial interests could be detected by the various proposals presented during informal discussions and by the mail received after the conference.

In summary, the results largely justified the extreme demanding efforts required during organizing and running of this conference.

7 - Results and Conclusion

The objectives of the conference:

- Valorization and dissemination of LASER technologies in three aspects:

  - Metrology, detection, control and non-destructive testing;
  - Processing of materials and increase of productivity of OSA;
  - Robotics and automation

were fully accomplished.

The vitality and viability of the Conference concept was reflected in the number and contents of the papers presented, the discussions and by the encouraging number of young scientists and industrialists participating and authoring.

This success of the Conference can be also evaluated by the number and diversity of sponsors and co-sponsors.

From the Conference general atmosphere it was felt that the relevance and continuous development of LASER technologies deserves a critical examination of the present status in research and development programmes in the field. In particular, whether a multinational programme should be considered, once almost

While organizing was in progress it was recognized that the scope of the Conference would result in a growth of the size of the event. This led to immediate action by a complete informatization of the organizing and of the texts editing and of the mailing providing a reliable back-up reinforcement.

From 3 parallel sections we were pushed to 4 parallel sessions plus poster sessions. Later the Opening session had to be anticipated. Specific interest on particular topics were better accommodated on two workshops. The Conference were then extended from 5 to 9th of June.

The audience also enlarge. From the 200 communications around 170 were selected. This scenario made us to think that the Conference should be split up between two Hotels pretty closed. The number of registered participants was still increasing so that it was definitely moved to the University campus to the modern building of the Faculty of Economics. This is a rather appropriate building complex with ample interior spaces and interior gardens (a building belonging to the National Patrimony of Modern Architecture!) where traditionally conferences are held all year around when supported by the University.

The University of Porto was very interested on this Conference so that the Opening session and Workshops where run under the patronage of the Rectorate of the University of Porto.

every European country has now its own specific mobilizing programme in the field. In parallel, education and training activities in the field need to be reexamined and its implications in curriculum development requirements eventually identifying necessities of sets of cohesive educational modules.

The workshop Lasers Technologies in Ocean Sciences has identified various needs in collective and synergetic actions. In particular the character of the topics in consideration calls for an European Conference proceeding along the proposed research Institute by SPIE.

In summary, LASER TECHNOLOGIES in INDUSTRY, was a very successful conference with full achievement of the objectives established and to the best proof left new and more demanding challenges to the participants.

Acknowledgment

The rapporteur and chairman of the conference would like to express profuse thanks to the DG XIII of EEC for providing the essential financial assistance to the conference and for the entrusting of this challenging project.

Sponsors and co-sponsors are to be thanked both for their kindness in the awarding of funds and interest on the conference. Exhibitors are acknowledged for their participation with live demonstrations of equipment and components.

Other Institutions providing complementary support are also acknowledged with gratitude. In particular, my own Institution, the University of Porto, is thanked for its constant support and active involvement.

Oliverio D.D. Soares
Porto, July 1988

LASER TECHNOLOGIES IN INDUSTRY

6-7-8 June 1988 ·· —— ·· PORTO ·· —— ·· PORTUGAL

ABSTRACTS

LASER TECHNOLOGIES in INDUSTRY is Supported by the Commission of the European Communities under the plan for transnational development of supporting infrastructure for innovation and technology transfer.

By courtesy of LNETI - Porto

SCHEDULE

OF

SESSIONS, WORKSHOPS & EXHIBITION

SUNDAY (JUNE 5)

(17H00)

OPENING SESSION (room A)

General (room A)	Optical Metrology (room B)	Laser Sensing & Optical Metrology (Cont.) (room C)	Laser Processing (room D)

MONDAY (JUNE 6)

(8H30)

KEY NOTE ADDRESS (room A)

(9H30)

General Overview (1 A)	Holographic Interferometry (1 B)	Optical Sensors (1 C)	Application to Robotics and Automation (1 D)
	(14H30)	(13H30)	(13H30)
(16H30)	Holography in Dynamical Phenomena & ESPI (2 B)	Laser Tech. Char. Particle Matter in Industry (2 C)	Laser Cutting (2 D)
Further Laser Applications (2 A)			
(17H00)			

POSTER SESSION MP

TUESDAY (JUNE 7)

(8H30)

PLENARY SESSION (room A)

(9H30)

Continuation (2 A)	Continuation (2 B)	Continuation (2 C)	Continuation (2 D)
	(14H00)	(13H30)	
	Computer Aided Holography (3 B)	Laser-Doppler Velocimetry (3 C)	
(17H00)			

POSTER SESSION TP

WEDNESDAY (JUNE 8)

(8H30)

PLENARY SESSION (room A)

(9H30)

Continuation (2 A)	Continuation (3 B)	Holographic Optical Elements (4 C)	Laser Materials Processing (3 D)
	(11H00)		
(14H00)	Laser Surface Inspection (4 B)	(13H30)	
Lasers in Medicine (3 A)		Moiré Holography (5 C)	(16H00)
			LCVD (4 D)

THURSDAY (JUNE 9)

(9H30)

WORKSHOP: Laser in Medicine

(14H30)

WORKSHOP: Laser Technologies in Ocean Sciences

EXHIBITION (Room E)

Open every day: 6-8 June

Laser applications in modern industries

Anthony J. DeMaria

United Technologies Research Center, Electronics & Photonics Technologies
Silver Lane, Mail Stop 77, East Hartford, Connecticut 06108

ABSTRACT

A short historical review, as well as trends in the laser industry will be be reviewed. The major portion of the paper will summarize specific applications of laser technologies in semiconductor manufacturing, material working, laser radar, electric power cable manufacturing, power recovery in gasoline refineries and nondestructive testing.

1. INTRODUCTION

The field of electronics was created by the invention of the vacuum tube at approximately the turn of this century. The heart of electronic technology is the device that amplifies the flow of an electron stream (electrical current) either in a vacuum (i.e., the vacuum tube) or in a solid (i.e., the transistor where the flow of positively charged "hole" can also be controlled with appropriate configurations). The word "electronic" was created by adding "ic" at the end of the word "electron." Since laser devices amplify the flow of a photon stream (light), the laser can be considered to be the heart of the technology that has been called quantum electronics in the past. More recently, some technologists have carried this analogy one step further and encompassed the field of quantum electronics; including, lasers, opto-electronics, electro-optics, acousto-optics, fiber-optics integrated optics, nonlinear optics, etc., into the new term "photonics" by adding "ic" at the end of the word "photon."

One should not jump to the conclusion that electronics and photonics technologies compete against each other. Instead of competing, these two fields complement one another. Photonics is heavily dependent on electronics technology. Photonics is useful for those tasks that cannot be performed by electronics technology. By performing such tasks, photonics has already created new segments of existing industries, and by doing so, photonics is further expanding the base of electronic technology.

One cannot help but notice the analogy between the role played by gas lasers and optically pumped solid state lasers in developing the industrial base of lightwave technology during the beginning of the field of quantum electronics and the role played by vacuum tubes in developing the industrial base of the radio/microwave/ millimeter wave portion of the electromagnetic spectrum during the early days of electronics. In addition, one cannot help but notice the analogy between the role the semiconductor diode laser and the transistor have played and are continuing to play in developing the industrial base of their respective spectral regions.

IMPORTANT FACTORS FOR RESOURCE ALLOCATION IN APPLIED RESEARCH AND DEVELOPMENT

E. U. Kotte
Nuclear Research Centre Jülich
Programme Group Technology and Society

ABSTRACT

Modern societies are at present in a critical period, i.e. confronted with problems of technological and structural change. The solution of these problems requires the reasonable allocation of capital, qualified workforce and organizational infrastructure. Particularly the human workforce in applied research and development can provide important contributions to technological competitiveness. Therefore, human factors and behavioural patterns should as well be considered relevant features in resource allocation. Even societies with long-lasting scientific and cultural traditions may require better analysis and adoption of factors like co-operation and self-organization, intuition and motivation for high-tech development.

The connecting link between the resource components capital, workforce and organization is determined by information technology as both the specific agent of historical change, and the ' asis for new developments. The provision of information in the meta-industrial society can influence patterns of innovation and diffusion, and lead to new perceptions of resource allocation. The behaviour of scientists and consumers will be stimulated by the professional dissemination and quality of knowledge. The exploitation of human resources can compensate limited resources in the financial and technical fields by means of enhanced information and promotion mechanisms.

INTEGRATION AND CONVERGENCE OF TECHNOLOGIES - A CHALLENGE FOR EUROPE

Werner Wobbe

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ABSTRACT

In this paper a long term fusion of microelectronics, photonics and functional materials in basic product components is assumed. Application fields are the opto-electronics in devices of communication technologies, sensors, laser informatics and measurement and control technologies in general. This movement is called the fusion of basic technolo ical families or optomatronics in a study for the FAST Programme of the Commission of the European Communities. The development towards optomatronics is seen in the long term as important as the movement towards mechatronics (the integration of electronics in mechanical products) which occurred since the mid 70's and was put into effect by industrial policies in Japan. It has caused turbulent impacts in mechanical engineering, machine tools, the clock and watch industry and precision engineering in Europe. The same turbulent impacts might arise for industries affected by optomatronic development. This should be counteracted by the appropriate industrial policies.

1. INTRODUCTION

In addition to other areas, the research programme for Forecasting and Assessment in Science and Technology - FAST - of the Commission of the European Communities, DG XII, has studied the industrial prospects for the "technologies of light" - microelectronics, product applications and new materials. In particular, the European research network for technologies of light has concentrated its efforts on:

- lasers and their accessories
- fibre optics and accessories
- systems for the capture, processing classification and exploitation of image data.

The outcome of this scanning, assessment and forecasting activity shows the importance of this technological family for industrial purposes[1] which has been over-shadowed by microelectronics. In resumption of these facts and consideration of other studies conducted by the research programme aimed at RTD policy consultation, a dossier[2] has been established which points out the strategic relevance of the fusion of basic technological families and its industrial impacts.

A central message of that dossier is that in addition to the process of introduction of microelectronics into electromechanical products, a similar process will occur with technological families which have already or will strongly enter into traditional manufactured products. They will substitute other technologies, create new products or improve the functions of traditional products. These new technological families are light (optical technologies or photonics) and functional materials. As already stated, the fusion of basic technologies (electronics, photonics and functional materials) in components and the integration of those components into products is called the move towards optomatronic related industries.

It is assumed that technological fused components will be just a part of a bigger product. Similar to the chip is the heart of microelectronics as a component for a calculator, machine tools, CNC control, etc. Optomatronic components will be integrated in products like measurement instruments, communication facilities or household equipment. They will particularly go into products or areas where today already electronics have had a breakthrough because fused components are associated with information, communication and control functions.

The move towards the fusion of basic technologies and its integration with traditional products is not directed towards a single industry. Like microelectronics[3], it influences a broad range of industries and can be called a generic or basic technology.

2. THE INTEGRATION OF TECHNOLOGIES

The integration and combination of technologies is a well-known historical phenomenum.[4] But it has now accelerated its pace, and will do so further. The traditional automation technologies in factories, as well as in households (washing machines, air

OPTICAL AND LASER TECHNOLOGIES

• The Next 25 Years •

ABSTRACT

The past 25 years of optical and laser technologies have seen optics transformed from a last-century, "dead" subject into a leading-edge technology, optoelectronics arise from the marriage of optics and electronics/microelectronics, and lasers discovered and developed into useful tools for science, engineering, medicine, and industry. The next 25 years will see these technologies mature and show their full capabilities. At least one expert has stated that within 20 years, virtually all signals will be transmitted optically. They will likely be processed and stored optically as well. Lasers will dominate industrial operations, many aspects of science and medicine, and commercial fields. In this paper we will review the major conjectures respecting the next 25 years of these technologies which may be made from extrapolations of present knowledge, with emphasis on industrial and manufacturing applications of laser technology.

These conjectures are as follows, without regard for their potential significances:

- *No really new types of lasers will appear; existing types will continue to evolve, with strengthening trends toward simpler, more compact, more reliable, lower-cost designs.*

TECNOLOGIAS LASER NA INDÚSTRIA

Conferência Internacional, 6 a 8 de Junho, no PORTO

Resumo da comunicação do
ENGº ANTÓNIO DA SILVA TEIXEIRA,
Director do BANCO DE FOMENTO NACIONAL

ÁREA : Avaliação das Aplicações Industriais

TEMA (Subject) : Entrepreneurial aspects for industrial applications of laser technologies.

RESUMO (Abstract) : In order that industrial applications of laser technologies, or other, may be successful in the markets, it becomes mandatory that they meet usual accomplishment criteria in the entrepreneurial world.

With that purpose it should be namely taken into account some factors, mentioned in the communication, such as, the development of favourable conditions to remove the difficulties involved for various levels of change, so the acceptance and implementation of innovations; the practice of industrial projects discipline, the respect for their requirements; the knowledge, acceptance and good use of the conditions, organization and rules that characterize the financial markets; the strategy and top management basic concepts.

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OPTICAL IMPLEMENTATION OF A NEURAL NETWORK USING SPATIAL LIGHT MODULATORS: DISCUSSION OF PROPERTIES AND PERFORMANCES

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Abstract:

In this paper we propose an optical design for implementation of neuronic Hopfield network. We use magneto-optic spatial light modulator and incoherent light. We describe the algorithm and its potential possibilities as associative (or content addressable) memory. We then describe the optical set and explaning its operating mode:

The operating speed is evaluate including the characteristics of the SLM "Sight-Mod" made from SEMETEX corp.: the maximun operating frequency is limited by the speed of the optical valve.

The low transparency dynamic of the SLM prevent to achieve an exact experimental realisation of the theoretical algorithm. The optical model is anyway efficient but it is necessary to know its operating noise. We describe this perturbations by analysing the two learning mode that are able to be made in the experiment.

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AN EXPERIMENTAL ANALYSIS OF NATURAL CONVECTION IN A ONE-SIDED HEATED VERTICAL CHANNEL WITH HOLOGRAPHIC INTERFEROMETRY

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SUMMARY

Natural, forced or mixed convection in vertical parallel-plate channels has received a fair amount of attention in the heat transfer literature, due to its importance in electronic cooling applications. In this work, an experimental analysis of natural convection heat transfer in an open-ended vertical channel has been performed, with either water or air in the channel and in the ambient which surrounds the channel. Governing heat transfer mechanisms and the temperature distribution in and out of the channel are observed by holographic interferometry.

HOLOGRAPHIC EVALUATION OF STIFFENER CONFIGURATION IN WATER BOXES OF AN INDUSTRIAL HEAT EXCHANGER

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ABSTRACT:

Holographic interferometry (HI) has proved to be very powerful tool for non-destructive testing/evaluation of many engineering components. This paper presents details of an experimental study on various stiffening configurations in the water box plates of industrial condensers having complicated geometry. The cover plate is clamped at the edges and loaded by transverse fluid pressure uniformly. It is highlighted that the effect of the behaviour of the gasket between the cover plate and water box shell on the deformations can be predicted easily and realistically by using holographic interferometry on a perfectly simulated model. It may be stated that a study including the gasket behaviour using finite element technique is very complex and expensive due to non-linear behaviour of gasket. Details of 'exact' simulation of the gasket in the test model along with those of holographic analysis are given in detail.

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HOLOGRAPHIC DATA REDUCTION PROCEDURE FOR TOMOGRAPHIC STUDY OF CONVECTIVE HEAT TRANSPORT

SUMMARY: High resolution multidirectional holographic interferometry using fringes of finite width provides data for the reconstruction of the temperature field in a convective air flow of a specially designed heat source which allows to introduce certain deviations from a cylindrical flow symmetry. The aim of this investigation is to adapt an appropriate reconstruction method of the interferometric data in analogy to the X-ray computertomography in medicine which gives sufficiently agreement with directly measured spatial temperature profiles. For the solution of this problem various inversion techniques are possible in principal. One of the most prominent is applied to our holographic data, the convolution method. The data gathering is achieved using a videocamera with frame store and recording interferograms within a range of nearly 180 degrees. The finite fringe interferograms are subject to a fast Fourier transformation, thus yielding increased accuracy of the determined phase distributions, which serve as projection data for reconstruction. The results obtained by the tomographical procedure are compared to the directly measured temperature values.

A New Full-Field Phase Shift Method for Holographic Interferogram

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There are many instances in holographic interferometry in which insufficient data is obtainable from the interferogram. An example is when it is difficult or undesirable to impose a high enough load on the component under study. The fringe pattern consequently is very sparse and the fringe order between the fringes cannot be accurately determined by interpolation.

In this paper, a new method for determining the fringe order at every point in an holographic interferogram is presented. The technique is based on being able to "shift" the fringe pattern so that a fringe is made to lie on the point of interest. This is equivalent to a full-field phase shift method, with the amount of shift required being a measure of the fractional fringe order at the point.

The experimental set-up and procedure are similar to those for conventional double-exposure holographic interferometry except that two reference beams are employed and during re-construction, the plane of polarisation of one the reference beams is altered. A quarter-wave plate and polariser are placed in the viewing plane. The fringe pattern can be made to appear to shift by rotation of the polariser.

The experimental technique and some typical results are presented and discussed.

SOME NEW TECHNIQUES WITH DIGITAL SPECKLE PATTERN INTERFEROMETRY

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Abstract :

Digital Speckle Pattern Interferometry (DSPI) has evolved as a useful tool for a number of engineering applications. We have implemented DSPI using a commercial 'Intellect 100' image processing system coupled to a PDP-11/23 micro-computer. A number of new techniques that have been developed using this system and the experimental results obtained will be presented.

In-situ Investigations of Deformations of Natural Stones by Electronic Speckle Pattern Interferometry (ESPI)

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ABSTRACT

Due to environmental stresses like weathering and pollution the deterioration of historically valuable monuments increases. A compact and mobile ESPI system is configurated and described, which allows the investigation of deformations in stones and walls in situ. A first measurement directly at a wall is presented.

1. INTRODUCTION

As a result of environmental stresses like weathering and air pollution the deterioration of human cultural heritage such as buildings, churches and monuments of natural stones, mural paintings etc. grows permanently. These damages are very alarming due to the fact that the monuments and works of art represent irretrievable treasures of artistical and historical cultural originality. They are in extreme danger since the continuously changing conditions of moisture, temperature, and pressure act in combination with pollution influences like SO_2, NO_x, CO_2 etc. This leads to chemical and physical processes that produce shearing forces in the heterogeneous stone material. The great number of environmental stress cycles may finally be responsible for the genesis of irreversible damages such as cracks or fracture. Such damages, for example, can be seen in fig. 1.

Figure 1. Damages like cracks and spalled regions at a Christ statue in Oberplaichheim, southern part of FRG. (Photograph by IBACH Steinkonservierung, Remscheid, FRG).

The investigation of the deterioration processes is of great importance to develop suitable methods of preservation and protection to prevent further decay. To study the dynamics of stone deformation electronic speckle pattern interferometry is a distinguished real-time method which allows non-destructive measurements in the order of magnitude of one wavelength of the illuminating light used.

2. PRINCIPAL CONFIGURATION FOR DEFORMATION MEASUREMENTS BY ESPI

When the rough surface of a natural stone sample is illuminated coherently, a speckled image is formed, which is characteristic of this surface. Deformation of the surface causes an according shift of this pattern. To measure changes of the order of one wavelength requires the superposition of a reference wave for out-of-plane displacements or the use of two illuminating wavefronts for in-plane displacements[1]. The resulting intensity pattern of

MEASUREMENT OF THE VELOCITY AND SIZE DISTRIBUTION OF DROPLETS AND OF THEIR STATISTICAL CORRELATION

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ABSTRACT

Although the methods used to measure the velocity and size of moving particles are very different and hence make use of separate apparatus, it is often possible to obtain both information simultaneously. The basic equipment requested for this technique is a standard laser doppler anemometer to which two slight modifications are brought: the photomultiplier is set so as to view the measuring volume at right angles and its's pin-hole is replaced by a slit. In these conditions, the electrical output of the photomultiplier can be best interpreted. The statistical correlation between the velocity fluctuation of the particle and that of its diameter is obtained by computing the joint probability density function of these variables from the probability density of the velocity and the conditional probability density of the peaks of the envelope.

This method does not require much investment on the optics which is standard; the effort is however transfered to the electronics, data acquisition and digital processing. Although it, is at present less accurate than those base on Fraunhoffer diffraction and gives relative values since it must be calibrated, it has the advantage to yield the velocity and size-velocity correlation. Moreover the electronics can still be improved and the processing speed increased by the use of a fast compiled language.

I. INTRODUCTION

The metrology of fluid dynamics seems to have been one of the most successsful applications of laser technology. This is due to the fact that the exploration of flows by this method is non intrusive as is not the case with traditional instruments such as pitot tubes and hot wire anemometers. The very nature of the laser which concentrate coherent light on a nearly parallel beam, reduces energy losses and makes it possible to use low energy generators. Moreover the analysis of the light scattered by particles (provided that they are spherical) is simpler.

The Laser Doppler Anemometry is probably the first laser technique used for velocity measurements. At its earlier stage, only one component of the mean velocity vector was measured but this was soon extended to two components by using a two color laser beam and now to the fluctuating velocities in turbulent flows.

Although it was well known that the light scattered by moving particles contained information concerning their size, it is only later that methods were proposed to extract it from the phototransducer output. These methods fall into two classes: the first is based on the concept of "visibility of fringes" and is only valid for particles with diameters not too different from the value of the interfringe (FARMER *), the second one draws the size from the pedestal signal.

The method described here belongs to this last technique. It has been retained because the optical signal is obtained from a standard L.D.A apparatus only slightly modified such as to reduce the influence of the paths of the particles on the phototransducer output. The latter is conditioned in order to to separate information relevant to velocity from that relative to size. The two resulting signals are then processed to yield the various data concerning velocity and size.

BURNAGE

ABSTRACT

Particle sizing instruments are used in many areas of applied science and engineering. In the fields of, for example, fuel nozzle development, combustion engineering, cavitation research and particle monitoring there is a need for nonintrusive measurements of particle dynamics: size, velocity and concentration distributions. Optical instruments are nonintrusive and provide the capability of accurate measurements with high temporal and spatial resolution.

Instruments for combined size and velocity measurements based on extensions to a Laser Doppler Anemometer have been under development for many years. The recent introduction of the phase-Doppler method represents a major improvement in the quality and reliability of these instruments. Compared to previous LDA based particle sizing instruments the phase-Doppler technique has a number of advantages: very wide dynamic range from micrometer to millimeter sized particles, high accuracy, in-situ calibration unnecessary and insensitivity to optical disturbances. These characteristics permit measurements to be made in harsh, previously unmanageable environments.

The phase-Doppler instrument combines optical, electronic and computer technologies. The present paper describes the operating principles and features of the instrument. Scattering of laser light by spherical particles is described as necessary for understanding the basic principles of operation. Additionally a method of concentration measurement (ref.5) based on automatic characterisation of the instruments measurement cross section is described.

The electronic portion of the instrument must measure the frequency and phase of high frequency transient signals, which may have a large noise component when measuring in severe environments. A unique electronic processor based on correlation processing techniques has been developed for this purpose. The operating principles and features of the electronics are described.

Lastly application of the instrument to the measurement of the droplet spray field from an atomizing nozzle is described. The measurement results include the size, velocity and concentration distributions of the droplets at a number of positions relative to the nozzle exit.

Particle size and an velocity measurement on flows of opaque or non transparent spherical particles by laser-Doppler-anemometry; problems of practical application

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In many applications of fluid atomization there is a high demand for point or overall measured data of size and flux of the liquid or solidified drops. For a few years the phase-Doppler-method (LDVS) besides of the Visibility/ Intensity-method has proofed out as a very usefull instrument for the analysis of such spray situations. In spite of the well known velocity measurement of particles by laser-Doppler-anemometry the particle sizing by this method is more complex and ask for both a more sophisticated electronic signal processing and above all a knowledge of the optical character of the particles under observation. The paper shows the influence of the refraction character of different spherical particles on the necessary evaluation of Phase-Doppler data. After a brief description of the Phase-Doppler-method including the basic physical principles it will be shown the Phase difference dependency of doppler bursts on different photodetector positions on one hand and on the refraction index and particle size on the other. For both transparent and non transparent particles there will be compared the results of the complex Mie light scattering calculations with simplified geometrical based calculations and experiments to find out dection angles which give unambiguous particle size informations and in addition allow an

experimental arrangement as simple as possible. The results show that in many cases where particles are not total transparent a back-scatter-arrangement of the photo-detectors should be possible. Although the requirement of particles sphericity may restrict the applicability of the phase-Doppler-laser-anemometry we should confirm that very often in multiphase flow systems the dispersed particles are drops or bubbles or if solid have a spherical shape. In the latter case we only need a sufficient smoothness of particle surface. The experimental results presented here are obtained from measurements on sprays of very different fluids, i.e. water, oil, enamel paint and molten metal.

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Studies of flocculation/ deflocculation of kaolin suspensions using LDS

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ABSTRACT

Kaolin suspensions have been the subject of many research works, not only for its industrial importance, but also for being particularly adequate for studies of particle/particle interaction, which in turn can be easily controlled by changing the properties of the suspending medium.

It has been shown, through rheology and sedimentation, that the floc, rather than the primary particle, is the fundamental unit.

The development of laser diffraction techniques for particle sizing has provided a new and easy way of tracing the formation and/or destruction of the flocs. A systematic study of the influence of PH, time and agitation, has been carried out using a laser granulometer (Malvern 2600) demonstrating that this technique can follow the phenomena occuring in the suspension.

It is believed that this kind of equipment represents a promising tool for a better insight of the flocculation process.

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Some Viewpoints on Laser Automation and Processing Quality Control

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ABSTRACT.

Since 1970 high powered lasers have been used in industry for cutting, welding and surface treatment. These operations are normally automated by some form of pre-programmed operation. None of the existing industrial systems incorporates process quality feedback control. The operating routines are all prefixed regardless of possible undesired changes requiring resetting of those conditions during operation. As a result the quality of products can not be guaranteed except by past experience. This problem has become increasingly apparent to industry and research scientists, particularly now that it may be soluble. Many attempts have been made to find a solution; so far they have served to show that the task is complex.

This paper reviews previous achievements in laser automation and process feedback control. It discusses some of the techniques which might be employed for future developments.

1. INTRODUCTION:

Not only is the laser a new source of industrial energy but automation has also advanced into new regions of sophistication. Open loop control has been with us since the industrial revolution, likewise some forms of closed loop control based on simple mechanical devices such as a speed governor on an engine. However the implications of closed loop control have expanded beyond the imagination of our fathers with the advent of the computer at prices which can be afforded for dedicated machinery. Larger computer memories and higher computer speeds have only recently opened up the possibility of a closed loop on the processing logic which leads to a form of artificial intelligence - or a machine which learns from experience. The laser opens up unique possibilities in automation. This is due to the 'noise' free nature of processing with optical power. The energy delivery system has no associated electric, magnetic, thermal or sonic fields other than those generated by the process itself. Thus the first step in automation, that of in-process sensing, is greatly simplified. The optical power from the laser can be rapidly switched, controlled or redirected fulfilling the second step required in automation. Thus it has been argued that the laser is an ideal partner for the robot.

This article looks at progress which has been made in laser automation and process quality control from the point of view of how it was then, is now and possibly will be tomorrow.

2. THEN -- AUTOMATED OPEN LOOP LASER PROCESSING SYSTEMS.
(Integration of the laser with a work table or robot) (1,2,3).

2.1. Automatic Operation - Speed and Position Control.

The first application of automation to laser processing was the automatic movement of the beam relative to the workpiece. This form of automation is essential for successful operation due to the precise nature and high speeds involved in laser processing - such as cutting, welding or surface treatment.

2.1.1. Automatic Movement.

The choice was to move the beam, the workpiece or both. Numerous designs have been suggested as shown in fig 1. The design points which have been found to be important are:

a) Positioning Accuracy:

The focussed laser beam is only around 0.1mm diameter, any deviation of this magnitude is likely to be visible on a cut edge or mean that a weld seam is not accurately followed. It has been suggested by Tight (1) that the market for laser robots is critically dependent on accuracy as shown in fig 2.

IPA

ROBOT GUIDED LASER FOR THREE-DIMENSIONAL LASER PROCESSING

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Abstract:

The laser is a non-contacting, forceless tool which is nearly free from wear. In regard to its tasks and its potential for process automation due to ease of control of the laserparameters, laser processing seems to be predestinated for flexible manufacturing. By the use of free moveable, robot guided laser-beamguiding-systems, the laser as a tool, offers a new potential for widely varied tasks.

In an overview on existing concepts for laser-beamguiding-systems, the possibilities for laser-beamhandling are discussed and system concepts of coupling laser-beamguiding-systems to a robot are presented. With the help of a pilot laserworkstation with a robot guided, free moveable laser-beamguiding-system, realised at the Fraunhofer-Institute for Manufacturing Engineering and Automation (IPA), the different components of a flexible laserworkstation are specified. Basing on this the principal explanations of robot-guided laser-beamguiding-systems are introduced. Different kinematic diagrams show the influence of the combination of laser-beamguiding-system and robot kinematic due to the workenvelope of the entire system. Investigations concerning the static and dynamic behavior of the system will show the requirements for a design of a reliable laser-beamguiding-system.

A consideration of the economy of different laserworkstations delivers economic indexes which show the cost ratio between the different variants.

laser cutting

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ABSTRACT

In this paper the laser cutting technology is shortly described. The history of the modern laser cutting technology is reviewed. The laser cutting process and its most important parameters are described briefly. Finally the trends in the technology is discussed briefly.

1. INTRODUCTION

The laser cutting technology is today the most widespread high power laser processing application, and more than thousand units of typical systems consisting of a 500-1.000 watt CO_2-laser combined with a two-dimensional CNC-controlled cutting table are performing high quality, precise short series of sheet metal cutting, mainly in mild steel, but also in other materials as for example stainless steel and aluminium.

The sheet metal laser cutting process is a thermal cutting process resulting in higher quality and precision than any other thermal cutting process. Therefore, the laser, although it is an expensive thermal heat source, is the common choise, when thermal cutting tools are applied to large, high precision CNC-controlled sheet metal shaping systems.

The development of the laser cutting process of today began with the development of the high power lasers. The major laser for cutting, the CO_2-laser, was developed in principle in 1963.[1,2] Through the following decade, the CO_2-laser was developed from the initial milliwatt output level to multikilowatt output range. Allready a few years after the first CO_2--laser was reported operating, lasers with an output power of a sufficient level for sheet metal cutting was developed.

Investigations in application of this CW laser source were initiated, and in 1967 the application of a coaxially gas jet for laser cutting was reported.[3,4] In the following 10 years, industrial CO_2-lasers were used mainly for cutting non-metallic materials, but still the industrial use of lasers for metal cutting was quite limited.

In 1979 the effect of the laser light polarization was discovered,[5,6] and the last technical obstracle to the industrial application of lasers for metal cutting was removed. In less than one year after the discovery of this major parameter in laser cutting, reflective phase-shift mirror coatings for high power CO_2-laser beams were available and soon the numbers of industrial sheet metal cutting systems available as well as the sales of these systems increased rapidly. The sheet metal cutting process was an established industrial production technology and the laser cutting application suddenly became the most important market for the high power laser manufacturers.

The laser cutting technology is however more than laser cutting. Industrial application of this cutting tool requires a system consisting of:

- laser source
- NC-controlled positioning system
- laser beam path
- cutting "tool" (lens/nozzle system)
- process gas supply

In addition to this production system, an efficient off-line programming facility is important to utilize the flexibility of the numeric controlled cutting system and finally the material flow around the cutting system is of importance.

To utilize the quality, precision and cutting rates, obtainable with a laser, strong demands on the speed and resolution of the NC-system and on the acceleration, speed and rigidity of the positioning system must be satisfied. It is clear, that the development of the laser cutting technology therefore not only was depending on the development of the laser source and the processing tecnique, but also on the development of the computer technology.

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THERMICAL MODELISATION OF LASER CUTTING PROCESS

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This paper presents a thermical modelisation of the laser cutting process, by means of a monodimensional approach along the direction of laser beam motion. This model, based on a finite differences method presents the advantage of simplicity. However, its numerical results are satisfactory.

This modelisation is applied to the case of metallic material. We investigate mainly, in the case of small thickness work-piece, the starting period of the cutting process, temperature distribution along the direction of the cutting front motion, and especially the influence of the exothermic character of oxydation reaction. This last approach shows a periodic behaviour of the laser cutting, linked to the instability of the laser beam/material coupling ; this instability is the responsible of the specific morphology of the surface cutted by laser, characterized by the existence of periodic striations on the cutted flanks.

This study enables us to understand some phenomena occuring on the cutting front, and to correlate our results with the observations of the cutting front during the process, previously made by several authors.

Heat Conduction and Mass Transfer in Laser Cutting

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ABSTRACT

The most important phenomena contributing to laser cutting are heating of the workpiece by absorbed laser radiation and exothermic reaction, heat loss due to thermal conduction and evaporation and melting of the workpiece in the vicinity of the focus of the laser beam. Material removal takes place since liquid material is blown away by the oxygen flow and due to evaporation. To obtain a deeper insight into these main phenomena of laser cutting and to understand their relative importance, heating of the workpiece and material removal will be closely regarded and analyzed.

The first part of the paper is devoted absorption of laser radiation and their dependence on the different parameters of the cutting process, as wavelength, polarization, angle of incidence and intensity of the laser beam employed for cutting.

In the second part the energy gain due to exothermic reaction bet ween oxygen and the material of the workpiece is discussed for the most important case, namely cutting of steel.

The third part of the paper deals with the analysis of the temperature distribution obtained in the workpiece under consideration of heat gain as treated in part one and two and under consideration of heat conduction and virtual cooling due to the movement of the laser beam over the surface of the workpiece.

Finally, the last chapter deals with material removal by melting and evaporation and the resulting cutting speed and their dependence on the process parameters. The paper is concluded by a discussion of the physical limits of laser cutting in terms of maximum cutting speed, ultimate thickness and cut quality.

CONSTRUCTION OF HOLOGRAPHIC MIRRORS IN DICHROMATED GELATIN

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ABSTRACT

Dichromated gelatin is a recording material for volume phase holograms. A properly recorded and processed hologram has a diffraction efficiency approaching the theoretical limit of 100%, high resolution and reduced light absortion and scattering, being the best recording medium to produce holographic optical elements. However, the influence of many of the physical/chemical parameters on the performance characteristics of the holograms is unknown.

The development of holographic mirrors is under way in our laboratory. Measures on the influence of some parameters on the optical properties of the mirrors and methods for their control will be presented : the degree of hardeness of the gelatin film, the penetration depth and spread uniformity of the Cr ions in the sensitized film, the energy exposure and the several development bath temperatures (hot and ambient temperature developments have been carried out).

DETERMINATION OF PRESSURE CHANGES IN FLUIDS BY MEANS OF GAS BUBBLES

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ABSTRACT

In this paper we present a new method for the determination of pressure fluctuations in a fluid. The objective is to perform this determination without any significant disturbance of the fluid.

The procedure uses gas bubbles in a fluid and evaluates dynamically the laser light scattered by the bubbles.

The technique could be of considerable importance to the study of cavitation.

Laser speckle size and temporal transfer function in human vision

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ABSTRACT

Using a blue laser stimulus we measured TMTF with speckle sizes of 19.1 μm, 3.3 μm and absence of speckle. Our results indicate, if we compare the TMTF curves obtained for different speckle sizes, a gain of modulation due fundamentally to the presence of the speckle; in the low frequency region this gain of modulation can be explained in terms of inhibitory effects. On the other hand, we observe by using the diffusion-inhibition model, that the presence of speckle in the test-field produces a delay of 12 ms and a reduction of the height of the response, with respect to that obtained in the uniform test (with absence of speckle).

1. INTRODUCTION

When a diffuser test is illuminated with coherent radiation its aspect is degraded by the presence of the speckle, that appears independently from the wavelength used just as long as the radiation is coherent.

The contrast and the size of the speckle are the properties in which we are interested. In general the study of stadistic properties of speckle is very complicated. However according to Dainty [1], *if we suppose that: 1) light is perfectly coherent, 2) the random* medium introduces phase fluctuations greater that 2π, 3) the medium does not depolarize light, and 4) a great number of scattering centres contribute to the intensity at a point in the observation plane, then, using the theorem of central limit, is relatively easy to prove that the intensity in a point is such that the speckle has a negative exponential probability density function. The ratio of the standard deviation to the mean is the unit for this distribution, for which we might say that the contrast of the speckle is equal to one. The minimum size of the speckle for which the above conditions are valid is approximately equal to the Airy disc that would be produced in the absence of the random medium. This indicates that the speckle in an optical image has dimensions in the same order of magnitude as the (aberration-free) limit of resolution. Therefore, the size of the speckle, considering the theoretical data of the eye, is given by the expression:

$$\tau = 20.35 \frac{\lambda}{D} \qquad (1)$$

in which τ and λ are expressed in the same unit and D (pupilar diameter) in mm.

As we know the numerous advantages that come from the use of coherent illumination, it is important to know how the speckle of that light affects the Temporal Modulation Transfer Function (TMTF) of the visual system. This TMTF gives us the temporal object image modulation changes produced by the system as a function of the temporal frequency, for any type of lineal system (optic, physical, biological, biophysical, etc), and it is a useful tool in the case of visual research.

Therefore our purpose in this experiment is to measure TMTF of the human visual system as a function of speckle size using a blue stimulus because previous studies on speckle size [2] suggest larger differences, between the curves corresponding to the extreme speckle size, are found with blue light.

2. METHODS

A complete description of the method used for measuring flicker sensitivity can be found in our previous studies [3].

2.1. Apparatus and Stimuli

The light source was a Spectra Physics 25 mw polarized He-Ne laser that provided us a red radiation of 632.8 nm and 4.3 nm bandwidth.

Light from the source goes through optical system with two channels S_1 and S_2, which illuminates the same test by means of a beam splitter.

Flicker stimulation is achieved by means of a modulator made with a rotable polaroid

NON CONTACT MEASURING MACHINE

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ABSTRACT

One of the problems of the production of cables is the measurement of the plastic coves at the production line.

If for some reason the thickness of the plastic is smaller than the minimum necessary several meters of cable may be lost. If the problem exists in the meddle of a long cable and the default is not detected in time, the lasers will be significant.

To solve this problem is possible to use automatic measuring machines which may detect a default as soon as it happens. It is also possible to interact with the production line in order to avoid any loses.

In this paper it is presented a non contact measuring machine, developed for this purpose.

The machine uses a laser which is scanned though a field of 80 mm. The interruption of the beam gives information about the external dimension of the object.

The technical study of the resolution, sensitivity and precision are presented on the paper. Also the hardware solution and the software are presented.

The machine has an interface which allows communication with a PC. The PC may receive information from several measuring units and to interact with machines installed at the production line.

The prototype is finished and is going to be tested in the industry.

Key words: Non-contact, measurement, laser, scanning.

AUTOMATIC MACHINE FOR SPIN TESTING

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ABSTRACT

One of the bottle necks of the defence industry is the fuze testing. This task must be performed twice for each fuze. It is a 100% test, since all the fuzes must pass two tests.

The arming test is performed at an high rotation speed, and it is necessary to guarantee that a minimum diameter is open. The non arming speed must guarantee that a small aperture has not happened.

The usual way to test the fuzes is the visual inspection by experienced operators. This method presents several problems and is always possible to have some faults.

To solve this problem, it was develcped a special purpose machine to perform this task in a completely automated way. The results of this development are presented in this paper. The optical system which incorporates a laser and the interface with the mechanics of the machine are analysed.

The prototype is installed at INDEP and being used for the automatic testing of the fuzes.

A description of the optical system and its characteristics are presented in detail.

HIGH PRECISION MEASUREMENT EQUIPMENT

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ABSTRACT

Based on the Michelson interferometer it was developed a measurement equipment to be used as a calibration system for the alignment of machine tools and measurement of planicity.

The equipment uses a He Ne stabilised laser and is capable of a resolution of 0,2 µm.

The results of the development are presented on this paper. The optical system, opto-electronics and optomechanical solution are presented in detail.

Among the applications, it is emphasised the measurement with this equipment of the planicity of high precision surfaces and the improvement obtained to conventional methods.

The equipment is ready for production and is now being commercialised.

LASER SCANNER FOR AUTOMATIC STORAGE

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ABSTRACT

The automated magazines are beeinq used at industry more. One of the problems related with the automation of a Store House is the identification of the products envolved.

Already used for stock management, the Bar Codes allows an easy way to identify one product. Applied to automated magazines, the bar codes allows a great variety of items in a small code.

In order to be used by the national producers of automated magazines, a devoted laser scanner has been develloped.

The Prototype uses an He-Ne laser whose beam scans a field angle of 75° at 16 Hz. The scene reflectivity is transduced by a fotodiode into an electrical signal, wich is then binarized. This digital signal is the input of the decodifying program.

The Machine is able to see barcodes and to decode the information.

A parallel interface allows the comunication with the central unit, wich is responsible for the management of the automated magazine.

THE APPLICATION OF LASER BEAMS TO ABSOLUTE PHOTODETECTOR CALIBRATION

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ABSTRACT

The importance of laser radiation sources in photodetector calibration processes is considered and shown. As an example of that, a recently made work comparing the spectral radiant flux measurement uncertainty of several absolute radiometers is described.

MAPPING OF TEXTILE SURFACE RELIEF

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We describe a system which is capable of mapping the relief of textile surfaces, by non contact optical means, designed to be used in textile engeneering laboratories to study the alterations produced in fabries by the action of dyes, shock, stress, and so on.

The specific nature of this materials precludes the use of conventional profiling systems, which led us to develop a new method with the necessary versatility but reasonably imune to dispersion, diffraction and speckle, phenomena which usually make very difficult the application of optical methods to this situation.

The method is based on the horizontal shift of the bright spot on a horizontal surface when this is illuminated with an oblique beam and moved vertically.

To make the profilometry the sample is sweped by an oblique laser beam and the bright spot position is compared with a reference position.

The system is so formed by an HeNe laser focused onto a reference surface (sample suport) endowed of bidirectional motion obtained by two stepping motors which are controled by a 8051 microcomputer that will also control the data acquisition and processing system, and it passage to the work microcomputer.

The laser beam incidence angle, the focusing system and the reception objective are cangeable to increase the system fickleness.

CONSTRUOÇÃO DE UM ANALISADOR DE PARTIOULAS

C.A.Couto[1], M.J.C.Romero[2], J.A. Fernandes[3]

Pretende-se construir um medidor de partículas baseado nas propriedades de difracção da luz.

As partículas a medir estão em suspensão num líquido em movimento que atravessa uma célula de paredes planas e transparentes. Sobre essa célula incide o feixe colimado e expandido de um laser de He-Ne. A luz difractada pelas partíoulas é coleotada por uma lente convergente em cujo plano focal se dispõe de um conjunto de fotodetectores dispostos radialmente.

Por análise das intensidades medidas são calculáveis quer o número quer as dimensões das partículas.

O sistema de captura será implementado com fototransistores de silíoio e celulas fotovoltaicas esoolhidas de acordo com as dimensões e intensidades luminosas

Depois de uma conveniente amplificação os sinais obtidos são introduzidos num microcomputador através de um conversor analógico-digital comercial de baixo custo.

O softvare a desenvolver permitirá para além da contagem e medição das partículas, controlar o caudal do líquido transportador.

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INSULATING MATERIALS FOR OPTOELECTRONICS

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ABSTRACT

Optoelectronics is an interdisciplinary field resulting from the interaction of Materials Science, Electronics Engineering, Information Theory and Fundamental and Applied Optics. Basic functions of an opto-electronic system include the generator of the optical signal, its transmission and handling and, finally, its detection, storage and display. A large variety of semiconductor and insulating materials are used or are being considered to perform those functions. In this conference, we will focus on the role of insulating materials, mostly oxides.

For signal generation, tunable solid state lasers, either vibronic or those based on colour centres will be briefly described, and their main operati parameters summarized. A reference will be made to some developments on fiber and waveguide lasers.

Relevant physical features of the silica fibres used for low-loss, long-band, optical transmission will be reviewed, as well as present efforts to further reduce attenuation in the mid-infrared range. The manipulation of the signal can be accomplished through the electrooptic, acoustooptic, photochronic and photorefractive properties of suitable insulating materials. Particular attention will be paid to photorefractive materials ($LiNbO_3$, BGO, BSO, etc.), which are being investigated at the Universidad Autónoma de Madrid.

Photorefractive materials constitute a particularly interesting

Abstract

The time-of-flight laser rangefinding technique has recently found many applications for industrial measurement purposes. The electronics of a rangefinder can be separated from the sensing head using optical fibres. In spite of many advantage such as non-sensitivity to demanding environments, optical fibres also introduce some potential measurement errors.

A NEW TYPE OF MODULATOR FOR INTENSE CO_2-LASER RADIATION AND ITS APPLICATIONS

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Abstract

This paper reports on a new type of modulator wich can be used for many applications of intense CO_2-laser radiation. The modulator ist based on the principle of the Fabry-Perot interferometer and acts as a beam splitter with variable reflectivity wich is placed outside the laser cavity. Be means of the tuning of the spacing between the two plane parallel interferometer slabs (e.g. Ge-, GaAs- or ZnSe-slabs) the intensity of the transmitted as well as the reflected part of the incident laser beam can be modulated. To achieve this tuning, one of the slabs is fastened to a stable diaphragm and is moved by using the principle of the dynamic loudspeaker.

In this simple manner some remarkable properties of the modulator could be realized by its special construction:

- Modulation frequencies up to several kHz independent on the parameters of the laser radiation and therefore on the CO_2-laser type;
- No influence of the modulation frequency on the peak power of the modulated light;

STRACT : Phase measurement open field laser diode telemeter for spatial rendez-vous and docking applications.

For about four years, collaborating with its industrial and scientific partners, CNES has studied the different types of optical sensors that could help to fulfil a shockless rendez-vous and docking mission between two spatial vehicles moving on a low or... around the Earth. As a part of that activities, a study realized by Sercel and CNES resulted in the definition of a phase measurement rangefinder able to measure distances from 2 to 500 meters with an accuracy varying from 20 millimeters to 40 millimeters at a rate of 1 Hz. The range and the field of view ($\pm 5°$) of that instrument together with specific constraints due to spatial environment lead to choose high power (100 mW) current modulated continous wave laser diode as lightning source for this application. As a matter of fact, the target satellite must keep passive during the mission. Furthermore, the sensor must work in open field to avoid the use of mechanical scanning systems and must be able to deliver a correct information even if the sun is in its field of view so that the rendez-vous scenario is not constrainted. Last, semi-conductor technologies have been preferred because their spatialisation seems to be simpler. Yet, a speckle phenomenon due to the multimode optical fiber onto which the laser diode is connected appears in the field of view. That phenomenon, associated to the dynamic behaviour of the component (spectral drift versus current intensity) prevents the sensor from delivering an homogeneous answer in different points of the field. The phenomenon has been analysed and a solution implying an adapted modulation for the laser diode is proposed. The global sensor principle is described.

ABSTRACT

The interconnection problems in the use of optical fibers for transmission signals processing is a very interesting line of research in the field of optical communications.

To solve the well known problem of lost of energy in the coupling procedure several methods have been studied and performed.[1-3] In those methods keeping the signal transmission efficiency appears to be the major condition to be satisfied. Among them, new techniques using holographic couplers present a high capacity of storage of the information, therefore, enlarging the signal transmission information, as well. Nevertheless, their coupling conditions appear to be very close related to the type of photomaterial as well as the register conditions, among them, the angular dependence and state of polarization of the incident light. We have obtained through the s~~c~~alar diffraction theory a very simple coupling condition relation where all physical optimization parameters involved in the coupling phenomenon can be easily controlled. By using a systematic numerical analysis we have obtained a scanning simulation at the output plane of the hololens-optical fiber system. The variation in the initial conditions of the incident light at the time of the holographic registrer makes possible to study the experimental situation for which the coupling condition would present the higher efficiency.

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Design of MESFET optical amplifier

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ABSTRACT

GaAs MESFETs, originally designed for microwave applications, have become an important component of receivers in high-speed optical telecommunication systems. For these applications, the crucial point in the device modeling is the evaluation of the induced gate noise and its correlation to the channel noise.

In this paper the design of a low-noise small signal optical amplifier using GaAs MESFET is carried out.

The principal noise sources of GaAs MESFETs are analyzed in order to completely characterize the equivalent model. Particularly channel-noise represents the dominant effect in the determination of the optical receiver sensitivity.

Total input noise current of the optical amplifier, due to correlated gate and drain MESFET noise, has been estimated in order to evaluate the excess channel-noise factor Γ for different values of photodiode capacitance. This procedure allowed to choose the photodiode with minimum noise.

At last, scattering parameters, minimum noise gain, gain-frequency dependence and bandwidth of the amplifier have been evaluated in the frequency range of interest.

1. INTRODUCTION

GaAs MESFET devices have become important components in high speed lightwave receivers[1]. For these applications, the crucial point in the device modeling is the evaluation of the induced gate noise and its correlation to the channel noise.

In this paper the principal noise sources of GaAs MESFETs are analyzed in order to completely characterize the equivalent model [2][3][4][5]. Channel noise represents the dominant effect in the determination of the optical receiver sensitivity [6].

The total input noise current in the optical amplifier, due to correlated gate and drain noise has been estimated in order to evaluate the excess channel-noise factor Γ for various photodiode capacitances.

At last, a low-noise small signal amplifier, operating in the S and X frequency bands, has been designed. Scattering parameters, minimum noise gain, gain-frequency dependence and bandwidth of the amplifier have been evaluated.

2. SMALL-SIGNAL NOISE EQUIVALENT CIRCUIT.

An equivalent circuit of the MESFET device, which includes noise sources, is shown in Fig.1.

At high frequencies, the principal intrinsic noise sources are related to the thermal noise in the channel and in the gate. They are expressed respectively by the following equations [7]:

$$\langle i_{nd}^2 \rangle = 4kT\Delta f g_{mo} P \tag{1}$$

$$\langle i_{ng}^2 \rangle = 4kT\Delta f \frac{\omega^2 C_{gs}^2}{g_{mo}} R \tag{2}$$

where $\langle\ \rangle$ indicates the mean square value, k is the Boltzmann constant, T is the absolute temperature, Δf is the bandwidth, g_{mo} is the transconductance, $\omega = 2\pi f$ is the angular frequency, C_{gs} is the gate-to-source capacitance, and P and R are quantities which depend on the bias and geometry of the device.

In Fig.1 are also reported the resistor thermal noise sources, expressed by:

$$\langle i_{n_i}^2 \rangle = 4kT\Delta f / R_i \tag{3}$$

where i is for g_1, g_s, s, o or dr.

ION BEAM PROCESSING OF MULTILAYER SEMICONDUCTOR STRUCTURES

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Ion implantation of GaAs/AlGaAs multilayer structures is an important semiconductor processing technique for optoelectronics. This technique has been useful in various stages of laser fabrication including electrical isolation, surface passivation, and material layer mixing. In this paper we report on the redistribution of implanted ions within such structures due to post-implantation furnace annealing. For this work GaAs/AlGaAs superlattices grown on GaAs substrates have been implanted with either hydrogen or beryllium ions and furnace annealed at temperatures up to 700 C. The implanted ions were then depth profiled using secondary ion mass spectrometry (SIMS). The measurements show that the hydrogen and the beryllium atoms redistribute depending on different activation temperatures and that both species tend to accumulate a the interface of the GaAs substrate and the epitaxial buffer layer. The concentration of atoms at this interface can exceed 1E19/cm-3 and may be related to the crystal perfection of the inital stages of epitaxy. The accumulation of implanted ions may lead to alteration of the optoelectronic operation of the material processed in this manner for laser applications.

ABSTRACT

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FEEDBACK INDUCED NON-MONOT`NIC BEHAVIOUR OF THE DIFFERENTIAL QUANTUM EFFICIENCY WITH THE CURRENT, IN InGaAsP INJECTION LASERS.

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and

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Characterization measurements on different semiconductor laser diodes point to an anomalous behavior of the differential quantum efficiency as a function of the injected current,just above threshold in the presence of an optical feedback.

This phenomenon and the appearance of a far air gap, that induces periodical changes in the output intensity,affect noise properties of the system.

Calculation of the Ambipolar Diffusion Coefficient through lasing action in gases.

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ABSTRACT

A new method to find the ion density of a gas at any time after the discharge is described. In this method the overvoltage of a fast discharge in a gas or its lasing action can be used. That is to say, knowing the experimental values of the actual starting voltage of a pulsed gas discharge or the laser output and comparing them with the relevant theoretical values, the ion density can be found. The result of this procedure is the calculation of the ion density at a time after the discharge equal to the inverse of the high voltage pulse repetition rate. Thus, by changing this pulse repetition rate the temporal behaviour of the ion density is found.

An application to the N_2 gas leads to the calculation of the ambipolar diffusion coefficient, the value of which is in sufficient agreement with the one in the literature.

1. INTRODUCTION

The research on the ion decay processes after a pulsed discharge in a gas is always important. This is because it finally leads to the comprehension of the ion behaviour and to the estimation of the coefficients of different ion decay processes. For example, such laboratory research on the gases existing in the ionosphere contribute to the understanding of the ionosphere properties.

In the afterglow of a gas discharge two main ion decay processes take place: the diffusion and the recombination. Being of a collisional microscopic nature, the recombination is a considerably more complicated mechanism in its details than the diffusion and it depends on the relative kinetic energies of the electrons and ions and, more importantly, of how energy and momentum can be conserved in the recombination process.

To examine these fundamental processes occuring in gas discharge the continuity equation for ion density is used. If the only ion decay process is the diffusion, then the continuity equation for ions is given by the relation.

$$\frac{\partial n}{\partial t} = D_\alpha \nabla^2 n \tag{1}$$

where n is the ion density and D_α is the ambipolar diffusion coefficient. To simplify, we can assume a fundamental diffusion mode with a decay time τ and rewrite

$$\frac{\partial n}{\partial t} = -\frac{n}{\tau} \tag{2}$$

where τ is the diffusion decay time. Its solution is given by the equation

$$n = n_o e^{-t/\tau} \tag{3}$$

If the electron temperature is equal to the ion temperature (T_e=T_+), then the decay time can be related to other quantities as follows;

$$\frac{\Lambda^2}{\tau} = D_\alpha = 2D_+ = \mu_+ \frac{2KT}{e} \tag{4}$$

where Λ is the characteristic diffusion length. This depends on the geometry and the container dimensions. For rectangular geometry of the diffusion space we have

$$\frac{1}{\Lambda^2} = \left(\frac{\pi}{L_1}\right)^2 + \left(\frac{\pi}{L_2}\right)^2 + \left(\frac{\pi}{L_3}\right)^2$$

D_+ is the positive ion diffusion coefficient, μ_+ is the positive ion mobility, e is the electronic charge, K is Boltzman's constant and T is the gas temperature. Thus, when only one type of positive ion is present in the afterglow, its mobility can be determined by a measurement of the time constant to the ion loss rate.

Off-axis elliptical zone plate for nonsymmetric Fourier transforming

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ABSTRACT

An off-axis elliptical zone plate (EZP) together with refractive optics has been used for obtaining the 2-D nonsymmetric Fourier transform (NFT) of a given object with parallel beam illumination. The NFT thus obtained is exact, excepting a linear phase factor due to the carrier spatial frequency used in the EZP recording. Experimental results show the ability of this system for separating quasi-unidimensional spectra of slightly different orientation.

1. INTRODUCTION

In the last years, interest for NFT systems working with parallel or spherical beam illumination has grown. Unlike the usual symmetric Fourier transformers, NFT systems redistribute the information at the Fourier plane in a nonsymmetrical way, giving rise to an unequal scaling of the u- and v-axes in the frequency domain. NFT systems are rotationally variant, performing a controlled deformation of the object spectrum. This fact is useful for many applications, in particular for obtaining superresolution in one direction[1] allowing to increase the angular discrimination between quasi-unidimensional spectra angularly very close[2] and to detect with greater sensitivity small misalignments in object orientation[3].

Until now, NFT systems were designed making use of conventional refractive elements (cylindrical lenses), being the design flexibility limited by the availability of well-corrected refractive phase transformers with proper characteristics. The use of a thin holographic optical element such as an off-axis elliptical zone plate allows to make easier this design, also reducing the number of required components.

2. NFT SYSTEM

The proposed NFT system is shown in fig. 1, being a modified version of the developped by Szoplik et al . The EZP transmittance function is given by:

$$t(x_4,y_4) = \sum_n a_n \, \psi(x_4, nF_x)\, \psi(y_4 + (1/nF_y)\sin\theta,\ nF_y) \tag{1}$$

where a_n is the diffracted amplitude coefficient corresponding to the n-th diffracted order of the EZP, $\psi(\alpha,\rho) = \exp(i\pi\rho\alpha^2/\lambda)$ and F_x and F_y are the two inverse focal distances corresponding to the two ortogonal primary focii of the EZP.

The object is located at the X_1Y_1 plane, a distance $f_x = 1/F_x$ form the EZP wich performs the Fourier transform along the X-active direction in the X_7Y_7 plane. The pair

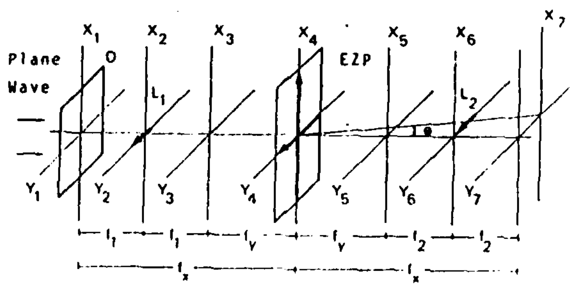

Figure 1. NFT system
The arrows indicate the active direction of each element.

Application of holography and ESPI techniques to earthquake prediction

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ABSTRACT

The laser holography and ESPI techniques are used for directly measuring crustal deformation in terms of fringe displacements in the interference pattern. These techniques will be useful to predict occurrences of destructive earthquakes.

1. INTRODUCTION

Since shallow earthquakes are most probably due to sudden release of strain energy accumulated secularly in the Earth's crust, continuous measurements of strain accumulation in seismically active regions are essentially important for the earthquake prediction. Over the last half a century, the geophysical strainmeters so called extensometers have been widely used for measuring strain changes caused by tectonic and tidal forces and seismic origins. Now, we attempt to apply the techniques of holographic interferometry and ESPI (electronic speckle pattern interferometry) to measure the crustal deformation quantitatively for the purpose of the earthquake prediction in Japan and studying the related geophysical subjects.

The conventional extensometer, in which a length of solid rod is used to measure the relative displacement between two piers fixed into the bedrock, can detect only one component of the Earth's motion, i.e. a linear strain between two points. On the contrary, the use of holographic interferometry or ESPI has the merit of detecting two- or three-dimensional strains simultaneously, of the order of the wavelength of the laser light. Moreover, these methods allow us to measure a small strain directly without contacting the object. The advantage of this is to be free from some of problems inherent in the conventional extensometers using solid materials such as the fused quartz tube or the super-invar bar. In these cases, it has been necessary to consider the effects from the frictional forces between the solid materials and their supports as well as the deformation of the materials themselves.

In the geophysical sciences, the laser holographic interference technique has been successfully used for measuring rock deformations in laboratory experiments.[1,2] It is, however, difficult under ordinary circumstances to obtain a hologram of a large object of more than 1 m because of environmental perturbations caused by atmospheric changes and artificial noise. Thus, strain measurements with holographic interferometry have been commonly carried out using small objects which have a dimension of 10 cm or so. In order to overcome this difficulty, we installed a holographic recording system in a deep tunnel where the temperature change was negligibly small and artificial noise did not exist. If an adequate laser source is provided for the system, holograms of large objects of more than 1 m could be obtained under the same conditions. Moreover, the tunnel wall itself is considered to be an object for holographic interferometry. Thus, the tunnel deformation caused by tidal and tectonic forces can be detected by analyzing the fringe displacement of the interference pattern.

2. HOLOGRAPHIC RECORDING

In 1984,[3] a laser holographic recording system consisting of a 50 mW He-Ne laser and associated optical elements was installed in the observation tunnel at the Amagase Crustal Movement Observatory, Kyoto, Japan, in which the various types of strainmeters and tiltmeters were installed and continuous measurements of crustal deformations using these conventional instruments have been carried out since 1967.[4] As shown in Fig. 1, the observation tunnel has a length of 1830 m and a gradient of 1/1300. The section of the tunnel has a horseshoe shape, with a diameter of about 6 m. The laser holographic recording system was installed at 320 m from the entrance of the tunnel and 130 m below the surface. The annual variation of temperature at that position is about 0.2° C and its daily

Measuring Rotating Component In-Plane Strain using Conventional Pulsed ESPI and Optical Fibres

by

Dr.Richard W.T. Preater

ABSTRACT

In-plane deformation of rotating engineering components may be measured using pulsed laser Electronic Speckle Pattern Interferometry (ESPI). The pulsed illumination freezes the component motion and avoids the stability requirements of conventional holography. The use of a high resolution television camera system and digital storage of the speckle images of the component surface gives good contrast interference fringe information immediately. In digital form this is readily available for image processing and fringe analysis techniques.

Conventional methods of strain measurement require the bonding of electrical resistance gauges and a signal read out. Non-contact optical techniques and a television system give a direct display of the in-plane displacement field, with immediate opportunity for scanning and locating the area of significant interest. Little or no surface preparation is needed and providing a non-load and live-load sequence is available during operation, no costly plant shut-down is required.

Early researchers in the field of ESPI with pulsed lasers suggested a limiting velocity of moving components of 2 ms^{-1}. Development for the analysis of rotating component displacements showed a limiting velocity of 50 ms^{-1} for the use of simple plane mirror optics. Novel optics, however, giving radial illumination of the component remove this limitation and clear interference fringes for radial displacements have been observed up to 150 ms^{-1}.

The recent advances in the design and manufacture of optical fibres means that the development of a fibre optic ESPI system now becomes feasible. In this way illumination and TV-imaging of totally enclosed or limited access components may also be included.

Abstract

Three-Dimensional Vibration Analysis Using Electronic Speckle Pattern Interferometry

Electronic speckle pattern interferometry (ESPI) is now an established experimental technique in vibration analysis, giving the advantages of non-contact, high sensitivity, full-field resolution, absolute quantitative measurement, and real-time observation. In vibration analysis it has until now exclusively been used with an optical configuration of in-line illumination and viewing, sensitive only to motion along the viewing axis. For simple objects this measures the out-of-plane (transverse) components of vibration. An alternative configuration, using two illuminating wavefronts at equal angles to the viewing axis, gives sensitivity purely to motion along on axis perpendicular to the viewing axis. This technique has previously been applied to static and quasi-static measurement of in-plane strain and displacement, but is here used for vibration analysis. This paper describes how by using three different optical arrangements it is possible to measure the vibration components on an object surface independently along three orthogonal axes, with all the advantages provided by ESPI. It is then a simple procedure to combine the components at any point vectorially to give the full three-dimensional amplitude and direction of motion. To demonstrate the technique, the vibration characteristics of a thick cylinder are analysed. This has different resonant modes corresponding to principally radial, tangential and axial vibrations, and also combination modes displaying mixtures of the above. The ESPI fringe patterns and the interpreted mode shapes are compared with predictions made from a finite element model of the cylinder, and the results show how the experimental and theoretical methods complement each other to give a better understanding of the object's vibrational response.

Summary

Out-of-plane and in-plane sensitive ESPI arrangements are used to measure the vibration amplitude of an object in three orthogonal components. The results are interpreted to determine the full three-dimensional mode shape, and are compared with finite element model predictions.

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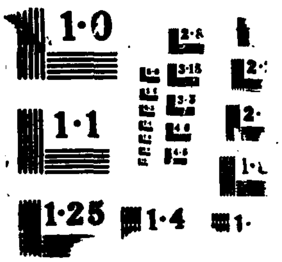
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ABSTRACT OF PAPER FOR: "LASER TECHNOLOGIES IN INDUSTRY"

" Developments in ESPI for Automotive Vibration Analysis "

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The Rover Group has been using ESPI for the vibration analysis of automotive assemblies for several years. Engines, suspensions, chassis, body shells and whole vehicles have been studied to assess their modal characteristics. A miniature, portable ESPI tranceiver, coupled by a 40m fibre optic umbilical to a 1W argon ion laser, is used to make measurements. Heterodyne modulation of the reference beam is incorporated, to animate phase and increase the system's sensitivity, by operation on the fibre optic with a piezo crystal. Sequential subtraction, time-average operation, coupled with a new digital processing algorithm generates fringes of approaching holographic quality, in real-time. The processing algorithm generates optimum signal to noise ratio fringes and exhibits high transient speckle noise rejection. This enables analysis to be undertaken on large structures under general test area conditions of restraint.

The system will be described and its operation outlined. Applications will be discussed and recent engineering applications of the system presented and contrasted with the use of alternative techniques of analysis.

Limitations identified will be discussed and modifications aimed at overcoming these will be presented. Future applications and developments will be outlined by way of conclusion.

OPTO-TECH LABOR DR. BREUCKMANN

On-line Fringe Analysis by Real-Time Phase-Shift-Processing

Abstract:

The significant progress that has been achieved in the last few years in the field of computer aided fringe analysis led to an increased interest in the application of a special group of optical measurement techniques in industry.
In particular for holographic interferometry, speckle interferometry, moiré and projected fringe techniques new areas for industrial application arise provided that fast and reliable automatic analysis systems exist.

This paper presents the concept of a real-time-processor for on-line analysis of fringe patterns which allows recording of phase-shifted fringe-patterns and successive analysis of the image data by the phase shift algorithm in video real-time.
In addition, examples will demonstrate the use of the phase shift processor in holography, speckle-technique, moiré and 3D measuring technique.

Software techniques for the analysis of contour maps of manufactured components

by

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Abstract

The precision measurement of the 3D surface form of manufactured components is an important industrial requirement.

The use of opto-computer techniques to make such measurements has great potential - being non-intrusive and capable of real time operation.

Frequently, the 3D information is generated by forming an optical contour map of the component.

Such optical methods as holographic contouring, moiré fringe contouring or fringe projection contouring are now widely used.

Any of these or similar methods will produce height contours which provide the z axis information which is missing from a standard photograph or T.V. picture.

By digitising such contours (either manually or automatically) a large sample of x y z data points can be transferred into a computer memory.

The Effect Of Shape, Structure And Texture On The Accuracy Of Size Characterization Of Fineparticles By Light Scattering

B.H. Kaye* R. Trottier**

ABSTRACT

Deconvolution of the complex diffraction patterns generated by laser inspection of a random array of fineparticles is a widely used method for characterizing the size distribution of the scattering fineparticles. Interpretive hypothesis used to deconvolute the diffraction pattern use simplified assumptions which usually ignore the diffracting effect of structural features of the fineparticle profiles. For quality control and processing research this is not a serious limitation of the methodology. However if one tries to use these methods to evaluate the size and concentration of respirable dust one must adjust the data processing involved in the deconvolution to take into account various structured features of the dust. In this communication the effect of sharp edges and fractal structure in respirable dust such as quartz, diesel exhausts, flyash and nuclear melt down fumes on the group diffraction pattern of a random array are discussed.

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Using Fast-Fourier-Transform (FFT) for the Phase-Doppler-difference-analysis of Powder Metal Sprays

TC 4

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Abstract of a paper for:
Laser Technology in Industry
June 6th - 8th, Oporto/Portugal

Using spray compacting processes like the Osprey-process for the continuous production of, for instance, plate products and avoiding further processes in order to obtain a full density final component, one is forced to measure the local mass flow rates as well as the local size- and velocity distributions of the molten and solidified particles on-line (and in-line). This also holds for powder metal spraying in order to receive rapid quenching.

Simultaneous measurements of the particle sizes and velocities based on the phase-Doppler-difference-method (LDVS) allow to analyze the spray cone and to give a description of their influence upon the cooling rate and thereby upon the material properties, i.e. the augmentation of the strength properties, the homogeneity of microstructure and the refined grain size.

Shrinking effects of the surface-"skin" caused by dendritic crystallization processes under rapid quenching boundary conditions or by amorphous material structures on the other hand influence the quality of the Doppler bursts which gets worse if rough surface structures give rise for diffuse reflection. But fast-Fourier-transform, (FFT), improves the success of signal processing in a decisive manner.

Like in laser-Doppler-anemometry measurements also in LDVS-measurements frequency estimation may be a problem especially if spherical solid particles with rough surfaces are under focus. The advantage of procedures employing the fast-Fourier-transform for this measuring task is their computational efficiency. Fast algorithms are available for common signal processor chips. For the LDVS analysis it is necessary to receive the frequency as well as the phase information from the phase-Doppler-data. Therefore the maximum of the FFT is taken as the frequency of the Doppler bursts and the phase difference between the transforms of two bursts at this frequency is used to calculate the size of the investigated particle. A processor which works in this manner may be used with signals of poorer quality resulting from small or rough particles, lower laser power, poor light detectors, back ground illumination, limited signal quantization or misaligned optics. The fast-Fourier-transform processor will be described in detail.

Control of Spraying of Molten Metals; An Application of Laser Doppler Anemometry

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Abstract of a paper for:
Laser Technologies in Industry
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During the last years the atomisation of molten metals has attracted a lot of attention because of its route of great technological promise, i.e. of a new generation of metal manufactoring processes by spray forming and making finished or semifinished products or i.e. of novel approach for rapid solidification and processing of high strength alloys.

The principle of all the spray forming processes is that molten metals or alloys are atomised in an inert atmosphere to generate a spray of liquid particles. Atomisation may be carried out by by means of high pressure inert gas, thus using the kinematic energy for generating very small droplets. The liquid particles are directed onto a cooler surface below the pressure nozzle, usually termed a substrate, where the particles impinge, flatten into the form of thin discs or splats, coalesce and solidify to produce a coherent deposit.

In all the preforming processes - in contrast to the production of powder metals - the spray result cannot be proved by sieving the product. Thus there exists a strong

demand for on-line measuring techniques which allow the in-situ-analysis of the most important spray parameters (such as drop-size and drop-velocity distributions, inertgas velocities, momentum distributions of impinging drops a.s.o.) in order to control the spray forming process under consideration of the molten metal flow rate, its temperature and regarding the solidification process in the preform.

The phase Doppler method, a modification of the conventional laser-Doppler-anemometry, allows this non-intrusive in-situ-analysis of all the interesting parameters and opens the possibility of spray forming process control, if the accepted data rates from the photodetectors will be processed in a very fast manner.

The measuring apparatus of the modified laser-Doppler anemometer (LDVS) has been integrated into the labor plant for spray forming of molten steel to flat discs on a rotating cooled or heated substrate-plate. The results from the first measuring-project will be demonstrated and explained. The facilities of the experimental set-up, i.e. the LDVS-apparatus with its special optical and electronical supplements as well as the melting devices and the tandon and the nozzle for the inertgas atomisation will be described and discussed.

Abstract of paper "On-line Measurement of Chrystal Size and Shape Using Combined Optical Techniques" to be presented at the "Laser Technologies in Industry" conference by Arthur Boxman and Prof. B. Scarlett.

At Delft University of Technology the UNIAK project is concerned with the development of control strategies for industrial continuous crystallizers. The new control scheme is based on actual information of the crystal size distributions in the various process streams taken from the crystallizer. The subsequent shifts in the size distributions are then used to adjust the process parameters according to this control scheme applied. The crystal sizes are measured in an on-line configuration of an instrument based on forward light scattering.

Instruments based on the principles of forward scattering have proven to be very succesful in determining particle size distributions, when the particles are typically in the range from 1 to 2000 microns.
Although the technique itself seems to be very straight forward, the results obtained may significantly deviate due to the light scattering model applied and the deconvolution step used for translating the recorded scatter pattern into a size distribution. Therefore a summarized survey is presented showing the influence of the various parameters in light scattering phenomena (e.g. size, relative refractive index, shape).
The data are then processed using an enhanced deconvolution step according to the derived light scattering model.

Besides the changes in the data processing strategy also a number of modifications in the measuring strategy had to made. The specific problems encountered are very high crystal concentration (30% wt), wide crystal size range (1 - 2000 μm), moving crystals (1 - 2 m/s) and the crystal being highly transparent.

At the moment a new system for measuring both crystal size and shape in an on-line configuration is being developed. This information is obtained by combining optical techniques based on the various ways in which light is introduced as well as received.
The subsequent steps are image capture, image transport, image processing and data reduction.

Abstract

"LASER-DOPPLER ANEMOMETRY IN HYDRAULIC RESEARCH"

by

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Mechanical measuring probes have been for many years the principal means to obtain information on fluid velocity in experimental Fluid Mechanics. Total pressure probes together with static pressure probes have provided the principal means of measuring mean velocity and hot-wire and hot-film anemometers the principal means of measuring instantaneous velocity values allowing mean, rms and velocity correlations determination. Undoubtedly, mechanical probes continue to be to important but their limitation make new measuring techniques worthy of being considerated.

Laser-Doppler Anemometry is an optical technique which allowing the measurement of the local, instantaneous velocity of tracer particles suspended in the flow does not disturb the flow. The availability of a measuring technique with such a characteristic is particularly relevant in Hydraulic Research Flows in ducts of small dimensions where mechanical probes can cause blockage or recirculating flows where those probes will disturb the flow pattern if used are some examples happening very often in practice.
A very common problem for Civil Engineer dealing with Hydraulic problems are the gate flows.

Gates are often used by Civil Engineers to regulate water levels and discharge flows from water reservoirs. So flows around submerged gates are of a far reaching interest and details of the flow structure have to be known for many applications. One of the questions in connection with this type of flows are the stability structural effects. Velocity information is required in order to access the performance of the gate and so see whether the gate will sustain the forces acting on it.

The paper refers to practical problems of gates already built as CRESTUMA-LEVER power plant gates. The macroturbulence is deeply changed by CRESTUMA-LEVER, movable dam, now in full operations in Douro river near Oporto. The gate structure is a eight double leaf vertical lift roller gates hook type, 28 m clear span, 13.7 m high. Being very big gates in a world scale one of the main problems is to avoid the tendency to vibrations.

The knowledge of the way the flow develops around gate is important. In fact most of the flow induced vibrations can be traced to a instability of the flow and so complete velocity and pressure fields around the gate should be known.

The paper describes Laser-Doppler measurements in this field and shows how this measuring technique can provide an insight into the structure of gate flows giving detailed velocity information and detecting regions of high shear within the flow where flow instabilities are likely to occur.

LASER-DOPPLER MEASUREMENTS OF IMPINGING JETS

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SUMMARY

Laser-Doppler measurements of the velocity characteristics of the flow field resulting from the impingement of single and twin jets against a wall through a low-velocity crossflow are presented and discussed together with visualization of the flow field. This study provides a basis to understanding more complex pratical flow fields, such as those in industrial environments where impinging jets complete with any cross-wind and the flow field created underneath a vertical take-off aircraft. The data is also suitable to evaluate the numerical solutions of the eo ations of motion which use turbulence models in order to predict this type of flows.

A cost-effective LDV system

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ABSTRACT

A low cost laser Doppler velocity measuring system has been developed, and is described in this paper. The principles of period measuring instruments are reviewed and the system parameters important to the measurement are considered. It is shown how the parameters may be adjusted to allow the development of a relatively low-cost instrument which does not have the high performance characteristics of some commercial instruments, but which is more than adequate in performance for most industrial applications.

1. INTRODUCTION

In 1964 it was suggested by Yeh and Cummings[1] that the velocity of a particle could be determined by measuring the frequency shift in light scattered as a particle or object passed through the beam of a laser. It was shown that the measurement of the frequency shift could be achieved by mixing, on the surface of a square law detector, the frequency shifted light with light having no frequency shift. Electronic square law detectors do not respond to optical frequencies, and thus they act as low-pass filters and so produce a difference frequency output proportional to Doppler shift, along with a signal component at zero frequency.

Since this early work there have been many refinements to the technique. A major development occurred in 1970 when Mazunder and Wankum[2] proposed the dual beam system. This has a very specific advantage over other systems since the observed difference in Doppler shifts is independent of the position of the observer, and consequently the setting-up of the system becomes relatively easy.

The measurement of the Doppler shift poses problems. Basically it is achieved by band-pass filtering the output of the square law detector to remove the zero frequency signal component and high frequency noise. This leaves a sinusoidal signal whose frequency is proportional to the velocity of the particle, but which is amplitude modulated and exists for a short time only. In practice the amplitude modulation of the signal is dependent upon the intensity of the light falling upon the particle. With a laser operating in the TEM_{00} mode this is Gaussian, and therefore the sine wave has a Gaussian amplitude modulation. The signal exists only for the time taken for the particle or object to traverse the laser beams.

Techniques which have been used to measure the Doppler shift include spectral analysis[3,4] and frequency tracking[5,6]. Commercial instruments are available using both of these methods, although the application of spectral analysis on a commercial basis is relatively recent and has waited for the development of digital signal processing techniques[7].

The authors have been involved with the development of digital systems for period measurement in laser Doppler systems for many years, and with the application of the instrumentation. They produced one of the first period measuring systems[8]. This has undergone a variety of modifications[9] and in its latest form is available on a single printed circuit board.

The laser Doppler velocimeter has developed mainly for research applications. It has proved useful in carrying out non-contact measurement in situations where conventional instrumentation is not available. However, developments of the application of laser Doppler systems in industry has been at a much slower rate than their development in the research environment. This is due to a variety of factors including the following:

(i) The technique is relatively new, and there is a reluctance by industry to introduce systems regarded as unproven.

(ii) The use of lasers, with associated radiation problems, has been a cause for some concern.

(iii) Measurement systems presently available are expensive.

(iv) There is a considerable amount of "know-how" required when applying laser Doppler systems.

In order to extend the application of the laser Doppler measurement system to more than

LASER DIAGNOSTICS OF THE FLOW IN INDUSTRIAL BURNERS

by

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SUMMARY

The stabilization of high intensity flames on multi-jet industrial burners is studied experimentally by laser diagnostics. Isothermal and combusting flow characteristics of the recirculating flow in the vicinity of a model industrial burner are presented and discussed together with visualization of the flow field. The experiments provide a basis to improving our understanding of relevant transport processes and of the mechanisms of flame stabilization in industrial burners of pratical interest.

Laser Doppler measurement of drive-belt slippage.

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Abstract

A laser Doppler system, measuring the difference in angular velocity between two rotating bodies, has been developed and applied to the measurement of slippage of a fan-belt in an automobile engine. The measurement is not affected by engine vibrations and elastic deformations of the belt.

RECORTE E GRAVAÇÃO DE MATERIAIS COM LASER DE CO_2

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RESUMO: Devido às suas características especiais, a radiação de um laser de CO_2 pode ser usada como uma eficiente ferramenta no processamento de materiais. Na presente comunicação dá-se conta do desenvolvimento de algumas aplicações possíveis com um laser de baixa potência (70 W) para recorte e/ou gravação de diversos materiais não metálicos - chapa acrílica, cartão, folha de madeira, pele, couro sintético, vidro, cerâmica, etc - bem como gravação de alumínio anodizado. Em cada caso foram procuradas experimentalmente as condições operacionais conducentes a resultados optimizados, actuando sobre parâmetros como velocidade de processamento, potência, gás de assistência, aspiração.

MARBLE CUTTING BY LASER

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The Laser Cutting System applied to marble presents several advantages over the conventional procedure acting by mechanical abrasion, wich are:

i) the absence of inhalation of heavy dust by the operator

ii) the inexhaustible capacity of defining the cutting profile

iii) no wearing out of the cutting tool

In the present work marble Laser cutting has been tried out with a fast axial flow CO_2 Laser in an attempt to optimize the cutting process, that is, to optimize the relation Cutting Speed vs Heat Affected Zone. For this purpose the Laser cutting were carried out varying the Laser output power, the cutting speed, the Laser mode (cw or pulsed) and the pulse length.

Tests were carried out on several plates of marble with different thickness and several characteristics such as texture, polish, color, and so on.

Also system characteristics such as focal length and assistance gas pressure were altered.

In order to have a better acquaintance of the process, the reflectivity of the marble were measured and subsequently plotted, as a function of Laser parameters such as power of the incident beam and angle of incidence, for the radiation of the CO_2 Laser.

A Laser System for Writing Photolithographic Masks for Integrated Optics

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ABSTRACT

Laser-beam writing system have already been tested, proving the validity of laser source for fabrication of integrated optical devices, or masks for them, with micrometric or submicrometric resolution.

Laser-beam system have used either manually- or computer-controlled stage. The latter, however, required long writing times to eliminate undesidered fluctations in the positioning of the stage. Recentely, we have developed a computer-controlled laser system for writing photolithographic masks over an area as large as 50mm X 50mm, based on an Argon laser and equipped with electronics that is both analog and digital at the same time. This enables one to computer programme the initial and final positions of any desired line and, above all, to obtain very smooth, perfectly linear displacements between them, which have none of the ripples typical of digital system. This system has an autofocus mechanism which, by means of a piezoelectric macrotraslator, controls, in real time, the reciprocal distance between the focusing optics and the mask to be patterned. This paper presents the system description and the laser-beam writing characteristics of some waveguide patterns. Indeed some preliminary results of assisted ion-exchanged channel waveguides fabricated directly into integrated circuit mask plates are presented.

LASER DIRECT WRITING OF GRATINGS FOR INTEGRATED OPTICS

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ABSTRACT

A novel technique for fabrication of thin-film gratings is reported. A CdS film, deposited onto an ion-exchanged glass waveguide, is photo-etched by a focussed Ar-laser beam. Computer-controlled movement of the sample allows for the formation of periodic structures, tested for input and output coupling. Some interesting effects due to the simultaneous presence of longitudinal and transverse gratings are discussed.

We also propose the technique in the realization of integrated optical devices for communications.

1. INTRODUCTION

Laser-controlled microchemical processes for deposition, etching and doping of electronic materials have become widely investigated since the early 1980s. A vast number of different technological processes has been demonstrated for various industrial and scientific applications, ranging from patterning to mask-repairing [1]. More recently, the possibility of employing photochemical-assisted laser-processes in microoptics and integrated optics has attracted novel interest with the availability of more sophisticated equipment and short-wavelength sources, such as excimer lasers [2]. In this work we report on the fabrication of gratings for integrated-optics applications by means of photo-enhanced dry-etching of CdS film with an Ar-laser source. The gratings were realized on planar optical guides, to demonstrate input and output coupling of light. The slab glass-waveguides were obtained by ion-exchanging Soda-lime glasses with Potassium ions. Cadmium Sulphide films, flash evaporated with good stoichiometry to a thickness of 1500-2000 Å, were laser-etched using an apparatus for direct-laser-writing, fabricating thin-film couplers with 1 to 2 μm periods. Experimental results are reported with the discussion of some interesting observed effects.

The technique, even if requiring some further improvements, appears to be quite promising in terms of applications to passive devices for optical communications. Typical realizable devices are input and output couplers, integrated Bragg reflectors, fiber-to-guide couplers and wavelength demultiplexers.

2. EXPERIMENTAL

In this section we describe the basic experimental procedures followed in the preparation of the final device. Due to the processes involved, each sub-section will outline the related technology.

2.1. Fabrication of planar glass waveguides

For the fabrication of slab optical waveguides, the well-known K^+-Na^+ ion-exchange technique [3] was employed with soda-lime glasses. The substrates, commercial microscope slides 1mm thick, cleaned in a diluted solution of Extran at 90°C, were preheated to 400°C and then immersed in a KNO_3 melt at the same temperature. The melt was contained in an anodized aluminium boat placed in a temperature-controlled furnace. Exchanged samples were allowed to slow cooling and then rinsed with distilled water.

The waveguides were tested by the two-prism coupling-technique using a low-power He-Ne laser source operating at 632.8nm. In agreement with the results reported by Yip et al [3], exchange-times of one hour allowed to obtain single mode (one TE and one TM) guides with an effective depth of about 2.5μm. Due to poor temperature-control, propagation losses always made the light-streak visible by out-of-plane scattering, although the in-plane scattering was quite acceptable. Best results were obtained with Corning slides.

Abstract

PROGRESS IN LASER FABRICATION OF MICROSTRUCTURES

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During the last few years novel laser techniques have emerged as tools for specialized material processing. Unlike already well settled power-laser applications, deposition or removal of thin layers from suitable substrates is now possible with spatial resolution in the micrometer range.

While microelectronic manufacturing and R&D have already devoted major attention to these new techniques, applications to microoptics, microchemistry and micromechanics are still to be developed, mostly due to lack of knowledge exchange between microelectronics and other fields. Our contibution to this conference is primarily intended for stimulating interest to the new techniques for non traditional - i.e. non electronic - applications.

The field of laser processing can be coarsely splitted in two: deposition of thin films and surface etching. Both thermal and photonic effects of laser light are involved, in most cases aimed at exciting precursor molecules - both in gas and in liquid phase - in contact with the surface to process. This results in a photochemical film deposition or etching, where the precursor supplies the material to be deposited on the surface or to combine with it. By associating a proper light assisted surface chemistry with the high spatial resolution achievable with a focused laser beam, "in situ" microfabrication is possible. Applications range from laser direct writing of electronic microcircuits to micromachining for optics and mechanics. A short review of laser processing is presented here, with specific application carried out in our laboratory.

Abstract summary

A review of laser microprocessing is presented, with applications in microelectronics and microoptics. The techniques developed in the author's laboratory are also shown and possible future developments are discussed.

ABSTRACT

SITPUL System allows the individual firing and tactical instruction of small units, under economical, safe and realistic conditions.

The system is composed by an Emitter, that uses a codified semiconductor diode laser beam to simulate the shooting of a weapon and by a Receiver that decodifies the information when a laser signal is dectected.

When the Emitter is actuated (by blank cartridges fired from the weapon itself or by a microswitch coupled to the trigger), a pulsed and amplitude modulated laser beam is sent, against the Receiver detectores.

The laser beam bears information that allows the identification of the shooter in wargaming for a maximum strength of 8,000 men, equipped with weapons of same or different types and codes for Kill and Near - Miss situations.

All this information, as well as the maximum number of firings in an exercise, is controlled by a low consumption microprocessor.

The Emitter unit is assembled to the weapons by means of adequate brackets.

The Receiver is mainly made up by:

- a trunk harness with 10 detectores positioned in such a way that ensures a adequate cover of the trunk vital areas
- a head harness with 5 more detectores
- a Receiver box with a built in microprocessor which registers the the identity of the emitter that reached receiver and the results of the combat (Kill and Near - Miss situations)

CHARACTERIZATION OF REAL LASER BEAM PROFILES WITH FEW PARAMETERS FOR METALLURGICAL APPLICATIONS

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ABSTRACT:

In first approximation the material induced effects after laser beam interaction are function of the whole transmitted energy and of the local "irradiance" (in $W.cm^{-2}$) levels and gradients. Consequently 3 informations may be able to describe this beam : carried power, shape and dimensions in the interaction zone. Thus shape and dimensions of a real beam would be simply and universaly described. If we are interested by the induced effects in the straight of the beam axis, 3 parameters are sufficient to describe the beam : the incident power P, an equivalent radius r^+, and an axial "spread" factor of energy distribution g(E). These parameters have been mathematically defined but they are also experimentally measurable (in particular from transmitted power through a small aperture or a slit localised in the vicinity of the work zone). The experimental characterization of 4 kW c.w. CO_2 laser (CILAS CI 4000) has been carried out for several powers (between 200 W and 3 kW). When the power increases it has been find that r^+ increases and g(E) stays nearly constant in spite of mode evolution. Presently the real-time evaluation of these parameters is investigating. Moreover these 3 parameters can be directly introduced in simplified analytical tridimensional thermal model, and so the behaviour expectation and the working parameters fluctuations effects (for example "mode" changes) become easier. At last this approach may be able to carry out "objective" comparison between the various high power lasers in different laboratories.

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<u>Conférence</u> : Laser Technologies in industry 1988 (Porto Portugal)

LASER BEAM SHAPING BY COMPUTER MADE HOLOGRAMS
MISE EN FORME DE FAISCEAU LASER PAR HOLOGRAMMES SYNTHETIQUES

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Le laser est devenu aujourd'hui l'un des moyens les plus utilisés pour chercher, produire, communiquer. Son utilisation croissante est due aux caractéristiques de la lumière laser : monochromaticité, faible divergence, cohérence spatiale et temporelle, énergie radiante pouvant être très élevée, impulsions ultra-courtes et possibilité d'accord en longueur d'onde.

Dans les meilleures conditions de cohérence spatiale et temporelle (cas du mode fondamental appelé mode TEM_{00}), le laser émet un rayonnement ayant une symétrie axiale et une répartition gaussienne. Cette forme du faisceau représente un inconvénient dans le cas où une illumination uniforme est exigée. Il faut donc dans ce cas procéder à une uniformisation du faisceau avant son utilisation pour des applications spécifiques.

Dans le cas particulier du traitement optique des données, et du jaugeage optique, un faisceau collimaté est nécessaire doté de plus d'une répartition homogène d'intensité.

Pour donner à un faisceau laser ces caractéristiques, nous proposons deux solutions distinctes basées sur deux méthodes et systèmes différents que nous avons conçus et réalisés utilisant chacun des hologrammes générés par ordinateur (C.G.H). Dans le cas où l'éclairage est suffisamment cohérent, une opération de filtrage linéaire des données d'entrée peut être réalisé en modifiant uniquement la transmittance dans le plan focal d'une lentille effectuant la transformée de Fourier. Nous avons conçu et réalisé un filtrage linéaire dans le domaine des fréquences pour établir le filtre correspondant. Nous considérons alors l'objet comme étant le faisceau gaussien collimaté pouvant être modifié par un filtre de fréquence spatiale (hologramme) pour produire l'image filtrée (faisceau uniforme). Nous avons ainsi constitué un système de traitement d'images très efficace. Nous utilisons la méthode de Brown et Lohmann pour synthétiser cet hologramme de Fourier (Réf. 1).

En s'inspirant du système afocal de Rhodes qui utilise une paire de lentilles asphériques (Réf. 2) permettant de transformer un faisceau gaussien collimaté en un faisceau uniforme collimaté, nous proposons une deuxième méthode. Pour cette méthode est conçu le deuxième système. Il sera constitué par deux filtres de phase substitués aux lentilles asphériques. Le premier filtre ou hologramme de phase servira à dévier les rayons lumineux de façon à obtenir une répartition uniforme. Le second filtre permettra de collimater le faisceau déjà uniformisé par le premier filtre.

L'utilisation conjointe de ces deux filtres repose sur le principe de la conservation de l'énergie entre les faisceaux d'entrée et de sortie. Le calcul que nous présentons aboutit à un système d'équations différentielles que nous avons résolu par la méthode de Runge-Kutta (Réf. 3). La première solution permet d'avoir un faisceau uniforme collimaté sur une distance relativement grande derrière la dernière lentille. Nous préservons ainsi la phase du front d'onde incident.

La solution qui consiste à substituer deux hologrammes de phase aux deux lentilles asphériques du système de Rhodes supprime la difficulté que représente les lentilles asphériques tout en offrant une efficacité élevée en transport d'énergie similaire à celle du système de Rhodes.

Ces deux systèmes et méthodes représentent en facilité d'utilisation et qualité du faisceau produit un avantage non négligeable par rapport à d'autres techniques plus anciennes utilisant des optiques compliquées, fragiles, chères et difficiles à fabriquer.

En conclusion, nous validons expérimentalement notre approche en p[illegible] qu'un faisceau laser collimaté peut être uniformisé par l'utilisation d'h[illegible]grammes synthétiques (holographie numérique). Ce procédé d'uniformisation sera, cependant, plus efficace si les techniques d'enregistrement holographiques sont améliorées. Ce qui signifie qu'il faut diminuer le bruit cohérent et augmenter l'efficacité de diffraction.

Nous proposons des solutions à cette fin et nous présentons au terme d'une discussion portant sur les principes et l'expérimentation, quelques applications techniques.

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DEVELOPMENT OF STABILIZED CO_2 LASERS

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LNETI/DEE (ÓPTICA)
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For applications like remote sensing and monitoring of atmospheric poluents, fusion plasmas diagnostics, among others, the CO_2 laser is an useful tool.

The degree of stability needed for such applications can be achieved by means of a well designed structure frame (with suitable materials) for the passive stabilization and some kind of optical cavity length fine control for the active stabilization.

Where it concerns the passive stabilization the choice of materials is a matter of great importance. The most common ones are materials of low expansion coeficient such as INVAR, CER-VIT or Quartz.

The fine control of the optical length can be achieved by means of a piezoelectric element which translates one mirror.

The error signal necessary for driving the piezoelectric can be obtained from several sources such as : the optogalvanic effect, the profile of the gain curve or by observing the beat frequency of two lasers.

We report the study of two lasers designed in the LNETI.
The results for passive stabilization were better than 10^6.
The active stabilization was achieved by means of the optogalvanic effect.

SPINODAL DETERMINATION IN POLYMER OLIGOMER MIXTURE IN SOLUTION BY LASER LIGHT SCATTERING

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In the compatibility study of high molecules still exists several dark points, particulary, in the case of the mechanisms to molecular level of the miscibility. The laser light scattering allows, if one of the two polymers is of very low molecular weight, to analize with precision phenomena such as the preferential solvation or the metaestability conditions of the mixture (spinodal). This can aid to understand the interaction mechanism of the species in solution. In this Comunication we study the spinodal of the mixture of poly(N-vinyl carbazole) with several poly(ethylene oxide) oligomers in tetrahydrofuran (THF).

ABSTRACT

A fast response Wobbe meter for natural gas is described. The working principle of the Wobbe meter is based on a relationship between the Wobbe index, the concentration carbon dioxide and nitrogen and the specific density of natural gas. The concentrations are determined by Raman spectroscopy.

A HeNe laser serves as the light source which generates Raman scatter in a cuvette filled with natural gas. A part of the scattered light is picked up and passed by two fibre optic cables to detection equipment. Filters are used to allow N_2 Raman light respectively CO_2 Raman light to pass. The power of the light passing the filters is determined by photomultipliers. The concentrations are calculated from the power of the Ramen light signals, the pressure and temperature of the gas flowing through the cuvette, the laser power and callibration data. The accuracy of the concentration meters is better than 0.25% (gas = 100%). This figure can be attributed to the statistical fluctuations of the intensity of the Raman light and to the way of estimating the background of the light signals. The response time is only 8 seconds.
The accuracy of the Wobbe meter is better than 0.25 MJ/m^3 which is good enough for a control instrument.

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SURFACE QUALITY ASSESSMENT BY LASER TECHNIQUE

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ABSTRACT

A method to assess the quality of solid surfaces is described using the photothermal deflection technique. The method is sensitive to local changes of optical and/or thermal properties of the inspected surface. Application to the quality of optical coating of mirrors is described.

INTERACTION PARAMETERS OF POLYMER-POLYMER SYSTEMS BY LASER LIGHT SCATTERING

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One of the most complex aspects of the study of mixture of polymers is the determination of interaction parameter χ_{12}. Recently, several authors has been proposing its determination on the basis of laser light scattering technique, in a solvent which its refractive index ranges between the refractive index of both polymers. These conditions are called "optical theta conditions". In this Comunication we show the results obtained of the study of interaction parameter of the Polystyrene/Poly(Methyl Methacrylate) mixtures in nitrobenzene, as a function of molecular weight of both polymers.

For the invited paper to the 1988 International Conference on Laser Technologies in Industry, 6 - 8 June, 1988, Porto, Portugal

All-Optical Wide-Area Remote Sensing of Dispersals of Unsafety Gases by Near-Infrared Absorption Based on Low-Loss Optical Fiber Network

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ABSTRACT

Optical fiber sensor technology is a subject of considerable interest and various techniques have been implemented for the measurements of a number of physical and chemical parameters. Based on the author's earlier idea in 1979 for a new capability of this technology, an optical network system employing low-loss optical fibers has been analyzed and examined for remote sensing of environmental pollution and spilled dispersals of combustible, explosive and toxic gases / vapors by the spectroscopic absorption method, in various industrial and mining complexes as well as in urban and residential area.

This regime of fiber-optic gas remote sensing has practically useful features because the optical energy can be concentrated and transmitted in low-loss optical fibers even for long distance over several tens km, instead of the open atmosphere. Therefore, a fully optical, reliable, sensitive, low-cost (with low-power lasers or even conventional nonlaser sources), feasible, real-time, nonhazardous, e.g., eye-safe and explosion-free technique can be realized for various stressing environments and severe conditions. This method also has the capability of little optical interference, and of continuous surveillance with easy calibration, wide selectivity, and no electrical induction.

The present paper summarizes and discusses mainly the basic subjects and experimental results of a low-loss optical fiber-based remote sensing system of various dangerous and polluting gases which have been investigated in my laboratory, with specific emphasis on the use of near-infrared wavelengths ranging from 1.0 µm to 1.8 µm for this purpose. Measured results of fully optical remote detection achieved in a diameter up to 20 km utilizing presently available very low-loss silica optical fiber links are also presented for hydrocarbons including CH_4, C_3H_8 and C_2H_4 in this wavelength region.

In-Situ measurement of ammonia with a $^{13}CO_2$-waveguidelaser system

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ABSTRACT

A laser gas monitoring system is developed to measure In-Situ concentrations of gaseous pollutants (our case: ammonia) at various temperatures. Heart of the system is a tunable $^{13}CO_2$-waveguide laser. By varying the resonator length the laser is frequency modulated between two neighbouring emission lines. One line is absorbed by the species investigated, while the other is used as a reference. By this referencing the system is auto-calibrated continously. The high spectral resolution of the laser method supresses disturbing influence of other species. A fast evaluation of the digitalised signal shortens the measurements time down below one minute. The lasers high output power is used in a multiple path arrengement, which allows the detection of ammonia concentrations in the one vppm range. First results of measurements in a power plant are reported.

Optical Detection of Bacteria using a Fluorescent Immunoassay

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ABSTRACT

Total internal reflection fluorescent immunoassay techniques provide a powerful method of detecting biological antigens and toxins. Experiments have been performed using two types of fluorescently labeled antibodies to two different antigen producing bacteria types. The sensitivity of the technique appears to be determined by the affinity of the polyclonal antibodies used to the specific antigen producing bacterial species. For a specific antibody-antigen system, the detection limit was as low as 10,000 cells/ml, while for more generalized polyclonal antibodies, the detection limits varied between different species producing the same antigen. It is hypothesized that these varying detection limits are a manifestation of variation either in the amount of antigen produced or in the actual molecular makeup of the antigens produced by related species. For tests performed using fluorescein isothiocyanate (FITC) labeled, affinity purified polyclonal antibodies to Salmonellae antigen, detectability varied from error free detection of several species at the concentration of 1,000,000 cells/ml. It is expected that with the development of suitable antibodies, the technique could be applied to the detection of virtually any toxin, and could be developed for in-situ monitoring applications.

Laser Systems for Bio-medical Applications

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The possibility to use the laser radiation as therapeutic tool in medicine is already established all over the world.

After a wide and deep investigation on the laser-tissue interaction, the laser is included today in the modern medical apparatuses.

Laser centers are located in Hospitals where the patients suffering of different deseases can take advantages of the properties of this new medical instrument.

Laser systems having CO_2, NdYAG, Argon sources are routinely used in many specialties. When combined with optical fibers they allow non invasive solution to interventions that previously required open field surgery. (Gastroentherology, Pneumology, Urology, etc.)

The laser has become a very important instrument in oftalmology for its capability to produce therapeutically significant photo-*coagulation (microsurgery)*. New laser systems as diode lasers have been suggested in this particular field.

Laser systems for tumor treatments and diagnosis, and for laser angioplasty will be discussed in detail for their present wide interest in view of in vivo applications.

SUMMARY OF ABSTRACT

ORTHOPAEDIC DEVICES EXAMINATED BY HOLOGRAPHIC INTERFEROMETRY

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The double-exposure holographic interferometry was used to study the mechanical proporties of the fractured human tibia supported by different fixing devices: osteosynthetic metal plate, intramedullar nail and external fixator. Differences in mechanical reactions to external load were analyzed for three types of fixation. Three different loading conditions were examined: compression, torsion, and bending. The mechanical advantages of the external fixation were pointed out.

Abstract

HOLOGRAPHIC ENDOSCOPY

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Although today endoscopy has established its place in many technical and medical disciplines, it has not yet exceeded the function of a qualitative, subjective observation method. Yet, modern diagnostic techniques increasingly require an objective, quantitative determination of form, structure and (micro-) movement of the - here endoscopic - object under study.

In principal, there are two approaches in developing a holographic endoscope:

1. Holographic recording in the tip of the instrument:
   In this case a large aperture (resulting in low speckle-noise) as well as a large focal depth are achieved and the parallax is maintained. Drawbacks are large outer diameter of the endoscope needle and the necessity to develop a comlete new type of endoscope (1).

2. Holographic recording with an external holographic camera:
   The construction of an external (endoscopic) holographic camera allows the use of conventional endoscopes. This means that also modern developments of endoscopes with extremely small outer diameter can be attached. These advantages have to be paid for by loss of parallax, small entrance pupil (resulting in an increased speckle-noise), and restrictions by the given optical performance data of the endoscopic optic like focal depth, spherical abberrations etc.

For the development of a holographic endoscope easy handling and flexibility are essential, which requires the use optical fibers (2).

Experimental results to overcome obstacles like the necessity of maintaining mode-structure and coherence of laser light by the use of special single-mode fibers as well as high (optical) power transmission capability for pulsed ruby laser applications as necessary for in-vivo investigations are presented (3).

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New devices for controlling the interaction of high-power laser light with anorganic and organic materials

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ABSTRACT

Two unconventional methods, which may be used in some cases to control heat conduction conditions responsible for secondary effects both in laser surgery and in laser material transformation, are presented. The tools developed for this purpose are based either on thermoelectrically controlled (TEC) or on thermodynamically controlled (TDC) temperature pattern generation around the acting laser beam. Using TEC laser scalpel secondary tissue damages may be avoided, while transformation hardening by laser radiation may be controlled through the thermodynamic effect known as Ranque-effect.

1. INTRODUCTION

High power lasers are becoming increasingly important tools in two areas of everyday life: in medical field, as a replacement of mechanical and/or electrical scalpel, and in engineering, as a noncontact method for material transformation. Their major role as an alternative or adjacent to existing methods is to alter, excise or remove material considered to be excessive.

Although the exact physical mechanism responsible for these effects is in most cases not entirely understood, there is no doubt that heat generated by the absorption of laser radiation plays an important role even in cases such as laser driven chemical reactions. The large absorption coefficient at a given wavelength assures the deposition of most of the energy in a rather small volume, thereby inducing a rapid temperature increase and resulting in high temperature gradient pointing from the surface not only into the underlaying material layers, but also in all directions on the material surface itself, thereby promoting the conduction of heat from the illuminated material layer to unexposed areas. This conducted heat may have an effect on the goal one wants to achieve by using intense laser radiation not only by depriving thermal energy from the area the property of which is to be altered, but also by varying the temperature of the nonilluminated area.

It can be shown[1] that if h is a distance from the point of attack P of the laser beam on the surface of question, the local temperature T_o will rise here as

$$T - T_o = (Q/4\pi Kh)\ \mathrm{erfc}\ (R) \qquad (1)$$

where $R = h/2(kt)^{1/2}$, and the thermal conductivity K is related to the thermal diffusivity k as

$$k = K/\rho c_m \qquad (2)$$

and Q is the thermal energy resulting from the absorption of the laser radiation at point P. The erfc (R) is an error function which is ~ 1 if R is small, and with the increase of R it decreases monotonously to 0.

Thus, the result of the interaction of intense laser radiation with matter in the vicinity of the point of laser attack strongly depends upon conditions of the energy transport through heat conduction which, however, could be influenced by the functions $\delta t/\Delta s$ and $\Delta h/\Delta t$ where $\Delta t = T - T_o$, and Δs the time interval in which the temperature change takes place.

We present in this paper therefore two methods which may be used in some cases to control the heat conduction conditions and, thereby, the 3-D temperature distribution in the vicinity of the impact point of the intense laser radiation.

In our reasoning until now we have made no distinction in the character of the material the laser light is acting upon, since the basic laws for laser-induced thermal effects are the same for both living and nonliving material, i.e., for biological tissue and engineering materials: the only difference is that the boundary conditions are not the same. This, however, means that tools that can be used in laser surgery to control some of the damaging heat effects may be practically the same, from engineering point of view, as those utilized to control laser material transformations. Therefore, we describe one of the methods sug-

Automatic Surface Analysis of Projection Intereference Fringes

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ABSTRACT

Projection fringe interferometry offers a powerful method of surface analysis. Two collimated coherent laser beams are projected onto the surface to be analyzed. The surface can be either an optical or non-optical one. The resulting interferogram is digitized and stored in a micro-computer. Special algorithms were written to automatically track the recorded fringes. The computer analysis performs noise reduction in the bias intensity of the fringes as well as the noise do to coherent laser speckle. Image processing of the interferogram results in a phase map of the surface. From this three dimensional topological mapping statistical parameters are evaluated to characterize the surface micro-structure. The parameters determined include: average roughness and the autocorrelation lengths. The geometrical optics designed can be set to obtain a surface resolution whose range can be varied from submicron to millimeter in both lateral and vertical directions. Surface areas to be analyzed can vary from microns to centimeters squared.

Results are presented for surface analysis of an oxidized roughly cut block of iron. In spite of the poorly reflecting surface, the projection fringe method was able to achieve good agreement with results obtained via the stylus profilometer method.

Surface Inspection of Laser Burnt Alloy via Three Dimensional Computer Color Contouring

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ABSTRACT

The inspection of a laser burnt alloy is performed via use of a microcomputer on-line to a digitizer which records the interferogram produced using projection interference techniques. The burning was performed via a high powered pulsed industrial carbon dioxide laser. The resulting burns varied in quality over the two surface dimensional. Surface micro-structures were analyzed using the recorded interferogram. Special image processing algorithms were developed to extract the burn features from the surrounding background.

Results are presented depicting variations in the burns. They reveal the quality of the laser pulse and its effect on different areas of the alloy. Lateral and depth resolutions of the order of a few microns were achieved. A topological mapping of the burns is presented as a three dimensional color contour of the surface.

SURFACE ROUGHNESS MEASUREMENT BY SPECKLE PROCESSING IN A DEFOCUSED PLANE

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ABSTRACT

The diffusing surface under investigation is simultaneously illuminated with two laser beams having different polarization states. Besides, each laser beam impinges the surface at a different incident angle. We employ an imaging optical system whose pupil mask consists of two laterally shifted circular apertures, each one provided with a polarising sheet. Therefore, at a defocused plane, two partially correlated speckle patterns are formed. Surface parameters, such as the rms roughness, can be obtained from the measured correlation degree by optical or electronic means. In the later case, real time measurements can be performed within 20 mseg. An advantage of the proposed method arises from its large measuring range.

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2 Member of the Carrera del Investigador Científico y Tecnológico del Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)

Paper to be presented at the 1988 International Conference LASER TECHNOLOGIES IN INDUSTRY, june 6-8, Porto, Portugal

A LASER RANGEFINDER FOR HOT SURFACE PROFILING MEASUREMENTS

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ABSTRACT

A time of flight laser rangefinder is described for use mainly in iron works where the profiles of converters have to be measured and its performance evaluated. The main problems are extremly high temperatures, usually about 1200 - 1400°C, a low reflection coefficient and a relatively long measurement distance, 10 - 20 m. Thus the signal to noise ratio (SNR) is low and averaging has to be used to achieve good resolution. On the other hand, the total profiling time has to be short enough that converters are not put out of production for any length of time. The rangefinder can also be used for ordinary passive targets at distances of up to 200 - 300 metres.

The laser rangefinder consists of three units: an optical measuring head, the electronics and a computer. The optical measuring head is connected to the electronics via optical fibres and contains parallel transmitter and receiver optics. Background radiation is reduced by means of a narrow-band interference filter between the lens and fibre head. The measuring head is mounted on a stand which contains angular sensors for measuring its horizontal and vertical position.

The electronic unit contains the transmitter, a receiver and time measurement electronics, which are controlled by a microprocessor.

The transmitter contains a s/h laser with an optical output power of about 15 W measured at the fibre head. The maximum pulse repetition rate is 5 kHz and the pulse width about 10 ns. The receiver electronics consist of a transimpedance preamplifier with an avalanche photodiode and two postamplifiers. The bandwidth of the amplifier stage is about 120 MHz. Gain control (AGC) is electronic, incorporating a pin diode attenuator and a constant fraction discriminator. The transit time of flight pulse is measured digitally by counting 100 MHz oscillator pulses. The electronics contain analogue interpolation circuitry, increasing the single shot resolution to about 50 ps (σ value) and thus reducing the measuring time. The electonic unit is connected to the computer via a RS232C serial interface.

The signal to noise ratio under the real measurement conditions is about 40 - 10 in the case of a hot converter where the temperature varies between 1100 and 1350 °C and the measuring distance is 12 - 20 m. The measured single shot resolution is about 400 ps (σ value) if SNR = 10, but improves as the SNR increases, to 70 ps (SNR > 70). The resolution can be improved by averaging to about 5 ps (1000 measurements). The measurement time is limited by the maximum pulsing frequency of the laser, and is less than 1 s when 1000 measurements are being averaged. The linearity of the system is limited by the AGC. The non-linearity in the 20 m measurement range has been measured to be less than 1 cm.

Summary of abstract

A laser rangefinder for profiling measurements of hot surfaces in steel works (t < 1400°C) is described. Measurements can be performed if the signal to noise ratio is greater than 10, and a resolution of few millimetres can be achieved with measuring times shorter than 1 second. The non-linearity of the rangefinder is less than 1 cm in the 20 metres measurement range.

WB 11

Eddy Current Nondestructive Evaluation of Laser Glazed Metallic Surfaces

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ABSTRACT

Laser glazing is the process in which a shallow surface layer of material is melted by a high power laser beam, followed by rapid solidification to produce a microcrystalline layer having improved resistance to wear, erosion, corrosion, fatigue and impact. The laser glazing process holds great potential for the production of new and improved materials, but there is a need to monitor and control the thickness of the glazed layer and to monitor porosity and other defects in the surface layer and adjacent substrate. This paper describes eddy current nondestructive evaluation techniques to characterize melt depth, evaluate microstructures and detect flaws in laser glazed metallic surfaces. Eddy current methods of nondestructive testing rely for their operation on the interaction of sinusoidally varying or pulsed electromagnetic fields with the metallic part under test. Such fields induce eddy currents in the specimen and the eddy currents set up their own electromagnetic field distribution which couples with the initial excitation field produced by a coil. This coupling effectively transfers the impedance of the test specimen to the excitation coil, so that changes in the test specimen which affect the transferred impedance may be detected by the excitation coil. Questions to be addressed in the paper include definition of experimental parameters of laser glazing of metallic surfaces, eddy current probe suitability for reliable measurement of thin layers, ranges of operating conditions, sensitivity, speed of response and feasibility of eddy current nondestructive sensors for use in process control. Results on hardness, thermal stability, wear and corrosion resistance will also be addressed in relation to materials of interest to the energy-related industries.

SILVER HALIDE SENSITIZED GELATIN AS A HOLOGRAPHIC STOROGE MEDIUM

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ABSTRACS

Silver halide sensitized gelatin is one of the most promising techniques for the manufacturing of transmision holographic optical elements. These techniques combine the relatively high sensitivity of photographic material with the low scattering and high light-stability of dichromated gelatin. The influences of the developer and the bleaching in the difraction efficiency and noise is analized starting with Agfa 8E 75 HD plates.

According to P. Hariharan, we analized the processing steps and this show that the developer action influences on the noise level and the modulation transfer function. The developer of the type PAAP produces better resolution and less noise level than the developer D-19.*

The bleaching action is related to the difraction efficiency and the hardering level of the gelatin. The hardering action is promoted by trivalent chromium ions which are generated in the vicinity of the oxidized silver grains and controled by the ratio concentration to the Cr^{+3} ions and Br^{-} ions of the bleaching bath. The measurements of the difraction efficiency in the different steps of the processing give us information about the mechanism of hologram formation.

We have obtained a holographic lens of 20 cm diameter with a uniform difraction efficiency which demostrates the posibilities of these processing tecniques.

**P. Hariharan, "Silver Halide Sensitized Gelatin Holograms: Mechanism of Hologram Formation", Appl. Opt. 25, 2040 (1.986).*

Abstract

A method of laser-beam scanning film thickness measurement based on monochromatic interferometory is proposed. To make possible the measurement within the range of 1 μ m to several tens μ m, small f-number holographic lenses are used and the good results are obtained.

DEVELOPMENT AND MANUFACTURING OF AN INTEGRATED MINIATURIZED HOLOGRAPHIC LASER-DOPPLER OPTICS

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ABSTRACT

In this report we present the up-to-date knowledge acquired in the design and manufacturing of an integrated LDV optics composed of holographic optical elements (HOE) recorded in dichromated gelatin layers. The holographic process used in this investigation facilitates the achievement of high diffraction efficiency and considerable miniaturization of the LDV optics.

The Measurement of Dynamic Displacement Fields and Strains Using Moiré Interferometry

J.W.Tong, H.Q.Li and Y.Q.Jia
Department of Mechanics,Tianjin University,China

ABSTRACT

This paper presents a solution to the problem of the displacement in a plane stress specimen with two half-circular hole during the propagation of stress wave after impact.

The solution was realized experimentally by means of moiré interferometry method using a double pulse Ruby laser. The load of impact was applied by a pendulum hammer

Two suitable external-trigger mechanisms was used to fire the Ruby laser at pre-determined intervals. The first and second exposure times are controlled respectively by a photocell and contact-trigger.We have made cross-line grating using a design of optical arrangement utilizing the technique of sticking holographic film. The holographic film is cement on the surface of specimen. We exposure twice before and after impact to the specimen and then pell the holographic film from the specimen. We develop and fix to the holographic film. We can observe moiré interferometry patterns when the holographic film is illuminated using white light. The moiré interferometry patterns of the U and V displacement fields were recorded on a holographic film at 23, 33,43,53μs after impact.

From the experimental data, a polynomial was used to express the U and V displacement functions using microcomputer. We can obtain the normal and shear strains of any point on the section of specimen.

Improvements in Moire'-Holographic Gratings for Structural Analysis

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Abstract:

The Authors present a simple method of gratings manufacturing on perspex models, used for structural analysis. The technique is briefly described and the quality and efficiency of grids are discussed. Two simple applications are illustrated.

THERMOGRAPHY OF LASER METAL-SHEET WELDING

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ABSTRACT

When a laser beam strikes onto a metal surface the electromagnetic wave penetrating the bulck converts itself into electronic excitation, and then into thermal, chemical, and finally mechanical energy. When welding thin sheets (100 - 400 microns) of low-carbon steel with a low power CO_2 láser, the work becomes difficult and very dependent on geometries and shapes of parts to be welded.

The state of the surface makes the emissivity (and absorptivity) very sensitive to the physical changes of the processes.

We have recorder the laser weld beads with an infrared camera and a video recorder. Power ranged from 20 to 200 Watt in CW operation. In pulsed regime, pulwidths from microsecond to tenths of second were used with repetition rates from 10 Hz to 15 KHz.

The images of the sequences were digitally processed resulting in a signifivative help in setting the appropriate parameters for welding, as well as to appreciate the real boundary conditions for modelling.

1 Student of Metallurgic Engineering
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Paper to be presented at the 1988 Internacional Conference LASER TECNOLOGIES IN INDUSTRY, June 6-8, Porto, Portugal.

Title: Stainless Steel Cladding of Structural Steels by CO2 Laser Welding Techniques.

Authors: A. LUDOVICO *, G. DAURELIO **
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SUMMARY

Steel cladding processes are usually performed in different ways: Hot Rolling Cladding, Strip Cladding, Weld Cladding, Explosion Forming.
For the first time, a medium power (2KW c.w.) CO2 laser was used to clad structural steels (Fe 370), 3 and 5 mm thick, with austenitic stainless steels (AISI 304 and AISI 316), 0.5 and 1.5 mm thick. The cladding technique we have developed uses the laser penetration welding process. It enables one to obtain cladded plates by making narrow weld beads, at high processing speeds (4 - 10 m/min), which penetrate the structural steel substrate through a depth varying from 2% to 20% of the cladded plate total thickness. So, mono- and bi-cladded plates have been made. Moreover, a cladding process called "mono-cladded plate with insert" was tested. In this kind of experiments, an austenitic stainless steel plate (AISI 304 or AISI 316) or a ferritic one (AISI 430) is sandwiched between a structural steel (Fe 370) and a stainless one (AISI 304 or AISI 316) to form a wafer-like structure. This was done to reduce at the minimum level the corrosion risks of the cladded elements, in the junction points. The influence of two different assistance gases (He, N2) was evaluated at varying processing speeds, on both mono- and bi-cladded elements. Furthermore, metallographic examinations and microhardness measurements were performed on the cladded plates in order to characterize this new laser cladding technique.

ABSTRACT

A laser cladding technique was developed. To do this, a medium power (2 KW c.w.) CO2 laser was used. Structural steel (Fe 370), 3 and 5 mm thick, was cladded with austenitic stainless steel (AISI 304 and AISI 316), 0.5 and 1.5 mm thick, thus obtaining mono- and bi-cladded elements.

Metal-Silicon Reactions with Laser Pulses

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ABSTRACT

The work done on the synthesis of metal silicides by using different pulsed lasers (ruby, Nd:glass, excimer) is presented and discussed. We found that excimer lasers offer much better characteristics for annealing of metal/silicon systems in comparison to solid state lasers.

1. INTRODUCTION

Integrated circuit technology has advanced significantly since the early years, when structures had feature sizes of 10 um and more, to the present time when devices with feature sizes of 0.8-1.0 um and junction depths of 0.1-0.2 um are produced. Nevertheless, the increasing demand for circuits with higher speed and higher component densities is leading to new circuit design and to new device structures based on innovative materials. Materials at every level of device architecture must be modified or replaced as circuit elements are decreased in size. Considerations of power loss and transmission speed are driving integrated circuit designers to lower operating voltages, where interconnect resistivity and uniformity become increasingly important.

Metal silicides are of great interest in modern integrated circuits technology to provide ohmic contacts, Schottky barriers, diffusion barriers, interconnects and so on. As metallization materials they have the advantage of being much lower in resistivity than polycrystalline silicon. Usually, metal silicides are produced by evaporation or sputter deposition of a thin metal film (typically 100 nm) on a silicon substrate (single crystal or polysilicon), followed by a heat treatment at an appropriate temperature (typically 1000 K; for 1000 s). The heat treatment is usually carried out in a vacuum furnace or in a furnace flushed with inert gas. This treatment poses some problems. In fact, the present trend in integrated circuit technology toward higher device packing density and decreased dimensions, requires low resistance thin film materials. But the used materials must present temperature properties compatible with other silicon processing operations. Near-noble and transition metal silicides are at present exstensively studied. Near-noble metal silicides form at quite low temperatures, but they can suffer phase transformations during subsequent thermal operations. In contrast, transition metal silicides are difficult to form and require annealing at very high temperature. The thermal cycle can result in significant dopant diffusion in the silicon substrate.

The main advantage of the laser annealing technique is then evident: the use of laser radiation, which deposits most of its energy near the sample surface, allows the reaction temperature for silicide

Microstructure and Oxidation Properties of Laser Clad $Ni_{70}Al_{20}Cr_7Hf_3$ Alloys with Extended Solid Solution of Hf

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ABSTRACT

Alloys coatings for superalloys for improved higher temperature (1200°C) service life under aggressive atmospheres are of great interest at present. There is a general consensus that addition of rare earths such as hafnium (Hf) to these alloys has a pronounced effect on the oxidation resistance properties at high temperatures. In situ laser cladding technique was used to produce Ni-Al-Cr-Hf alloys with extended solid solution of Hf in a near stoichiometric Ni_3Al matrix. A 10 kW CW CO_2 laser was used in conjunction with a screw-feed powder dispenser to perform the in situ cladding process. Premixed alloy powder from the feeder was allowed to fall onto the substrate (Rene 80, a nickel based superalloy) at the same time and location as the laser beam in order to form the cladding. Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), and Scanning Transmission Electron Microscope (STEM) attached with Energy Dispersive X-ray (EDX) analyzers were employed for microstructural evolution studies of alloys produced during the laser cladding process.

The microstructure of these alloys mainly consist of dendritic cell of γ'_p which is of the Ni_3Al type with about 11-14 wt% Hf and an interdendritic eutectic phase. Aluminum in the Ni_3Al was found to be partially replaced by Cr and Hf. Although there were some subtle differences in the cell spacing, composition and other minor features between the samples depending on the process parameters, no radical differences were observed. Based on the observations made, the possible phase transformation sequence of this group of laser clad Ni-Al-Cr-Hf are suggested below.

$$\text{Liquid}(L) \rightarrow \gamma'_p + L \rightarrow \gamma'_p + E \rightarrow \gamma'_p + (\gamma'_E + \delta_E)$$

where γ'_p is primary γ' phase with ordered f.c.c.. structure ($L1_2$), γ'_E is eutectic γ' phase with ordered f.c.c. structure, and δ_E is the other eutectic phase with heavily faulted f.c.c. structure. E represents the eutectic phase.

The eutectic phase is a mixture of two phases, one Hf rich and the other Hf lean. Dark field microscopy in the dendritic zones reveals ordered domains and the morphology of the domains depends on the process parameters used during laser cladding. Convergent beam electron diffraction and x-ray spectroscopy have been applied to characterize the phases formed during the cladding process. Initial Differential Thermal Analysis (DTA) work indicates that the γ' dissolution temperature for the claddings is at least as high as the substrate material (Rene 80) if not higher.

In order to evaluate the oxidation response of the claddings with respect to the substrate material, thermogravimetric analysis (TGA) was carried out in a TGA unit. Single cycle oxidation tests of eight hours at 1200°C in slow flowing air reveal that the claddings have a lower weight gain rate than the substrate itself. Microchemistry and microstructure of the oxidized samples are examined using SEM attached with EDX and Auger Electron Spectroscopic (AES) techniques. The oxide scale in this system is primarily Al_2O_3 and the improvement in the oxidation resistance is believed to be at least partially due to the formation of mechanical pegs of hafnia, which hold the alumina on to the substrate and prevent oxide spallation.

Theoretical modeling of diffusion was also carried out to estimate the extent of the extended solid solution in laser cladding. By incorporating a nonequilibrium partition coefficient for dilute solution the model was used to determine nonequilibrium phase diagram for Ni-Hf and Ni-Al systems. The theoretical prediction compares well with experimental data.

I. INTRODUCTION

Alloys for coatings for gas turbines require superior mechanical properties and oxidation resistance at elevated temperatures (1200°C) and aggressive environments. In recent years attention has been focussed on developing suitable high temperature oxidation resistant protective coatings for nickel or cobalt base superalloys for enhanced service lifetime. M-Cr-Al-RE (M = Ni, Co, Fe and RE = rare earth) systems are widely used for such coatings. These coatings, when obtained using the right proportion of the elements tend to form Al_2O_3 rich scales. Al_2O_3 is the coating of choice because of its limited volability, sluggish growth kinetics, relatively inert behavior and also because oxygen diffusion through the oxide scale is also extremely small.

LASER SURFACE TREATMENT OF A X42 Cr13 (DIN) TOOL STEEL

R.Vilar, R.M.Miranda and A.S.Oliveira*

Summary

Results of a structural study of laser surface treated samples of a martensitic stainless steel containing 0,47%C and 12,8%Cr are reported.

Abstract

Samples of a martensitic stainless steel containing 0,47%C and 12,8%Cr in the annealed condition were treated using a continuous wave CO_2 laser radiation.

The heat treatment was conducted both with and without surface melting; besides, the power density and the interaction times were varied.

The microstructure of the laser modified layer was studied by optical and scanning electron microscopy, X-ray diffraction, as well as by hardness tests.

Surface topography was characterized by scanning electron microscopy and rugosity measurements.

The melted zone presents a narrow region near the fusion line that seem to have solidified with a plane solidification front followed by a cellular-dendritic structure in the center. The structure is martensitic with large amounts of retained austenite. Interdendritic porosity and hot cracks were observed. The rugosity of the surfaces is dependent on the surface finish before treating.

Samples treated without surface melting exhibit large amounts of undissolved carbides, resulting on a more heterogeneous structure.

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Short Abstract

ALUMINIUM REFLECTANCE UNDER EXCIMER LASER IRRADIATION

by

A. Anedda, A. Mura, F. Raga and M. Cappai

Dipartimento di Scienze Fisiche - Universita' - Cagliari - ITALY

The reflectance of cold rolled Alluminium during excimer laser pulse irradiation with power densities in the range 3 MW/cm^2 - 20 GW/cm^2 has been investigated: plasma formation at 500 MW/cm^2 without previous melting at lower power is observed.
Previos "laser cleaning" of the surface lowers melting and plasma threshold to the pure Alluminium values.

PROGRESS IN LASER CHEMICAL VAPOUR DEPOSITION OF SILICON THIN-FILMS

Laser chemical vapour deposition (LCVD) has been attracting a considerable amount of interest to deposit silicon films, which are the most commonly used semiconductor material |ref.1|. LCVD can be categorized in several ways, one of which is according to whether the laser energy is used as a heat or a photon source to the reaction. In this paper we will discuss the progress obtained from a series of experiments of several laser-based methods. Different kinds of lasers have been used, as for instance the CO_2, Nd:YAG, Ar^+ and others, either in the pulsed or CW modes. Depending on the kinectis processes of the molecules used to deposit silicon, twin-beam, perpendicular beam or tangent paralell beam processing can be employed for the control of the deposition rate, morphology and adherency of the films. The growth mechanisms of these films will be discussed.

Ref. 1 V.Baranauskas et al, Appl. Phys. Lett. 36, 930 (1980).

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LASER TECHNOLOGIES IN INDUSTRY

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PREFACE

LASERS - The core of the scientific-industrial Photonics' revolution

Albert Einstein in 1917 states that nature includes an unnoticed phenomenon - the stimulated emission.
Perception of the scientific and technological consequences of this discovery become definitively evident in 1960 with the realization of first LASER by T.H. Maiman.
One of the most important technological inventions of the century initiates an explosive perculation, practically in every field of science, technology and biomedicine.
The illuminating power density, directivity, coherence, monochromaticity and polarization of LASER radiation are ingeniously controlled in a broad variety of LASERS to the achievement of striking conquest from a multitude of perspectives:

- Time is measured and discretized on a femtosecond scale
- A highly collimated beam is retroreflected from the moon to the earth measuring the travelled distance with a precision of half of meter
- A glassy sphere fluctuates in the vacuum supported by a LASER beam
- Deformation and vibration of surfaces are measured with precision beyond 0,05 nm
- Focalized LASER beams can trigger the nuclear fusion mechanism
- Multikilowatts of energy power can be concentrated in a LASER beam of diameter smaller than a finger

LASER applications become intense, extensive and sometimes unique.
Novel techniques for materials processing emerge. The telecommunications and data links progressively are transformed in optical communications with potentialities and capacities unimaginable fifty years ago. Holography abounds with its capabilities in metrology, recording and information processing.
The applications increase in diversity. As sampled examples: precise measurement of large distances, alignment of gigantic structures, LASER spectroscopy, granulometry and LASER anemometry, etc, etc.
A new era in science and technology rapidly grows under the broad name of PHOTONICS.
The introduction of video-disk, LASER surgery, LASER printers, etc. in the consumer market makes the people feel at large, in the quotidian effects of the photonics revolution.
The technological impulse will be felt all across the economical network and professional tissue.
LASER engineering will come as an autonomous field with expected unprecedent increasing impact in industry where more and more practical and cost effective applications are being established, materializing already a big LASER market. Worldwide sales of commercial LASERS reached $570 millions in 1987 (1)with claimed annual growth rates reported around 20% for the last few years. Continually improvement of LASER system characteristics, in particular, coupled to computers and industrial robots, combined with an anticipated increase of economical performances on the LASER uses and their inherent ability to find new niches is expected to bring soon an even more worldwide spreading of LASERS applications.
Sophistication and flexibility achieved in LASER metrology, sensing and control techniques by incorporating novel methods of automation and image processing with recourse to computers has stimulated a broad range of applications both in industry, science and biomedicine.
The LASER appears also as a unique industrial energy source. The optical power produced from modern LASER equipment is in the range of 100 - 10,000 W. A form of power that is absolutely chemical clean, easily shaped and controllable both in intensity and direction. No magnetic field effects or hot jets are associated.
The LASER is thus an ideal partner for a robot or an automatic process due to this great flexibility (2).
Industry has been quick to appreciate this new tool. There has been a vigorous growth of new industrial processes based on LASERS, and this is particularly so in material processing (cutting, drilling, welding, surface treatment, bending both in theory and practice).
The European Community also responded timely to the necessity to keep Europe in the forefront of this exciting technology through the many initiatives such as in BRITE and EUROLASER. The Conference LASER TECHNOLOGIES in INDUSTRY supported by the EEC - DG XIII, Directorate-General for Telecommunications, Information Industries and Innovation under the SPRINT programme is yet part of such an understanding.
LASER TECHNOLOGIES in INDUSTRY conference was indeed planned to be an interdisciplinary forum for presentation of the current uses of LASERS wishfully reflected on the proceedings intended to provide the potential user with a coherent view of update developments, financial involvement as envisaged benefits.
Recognized world experts presented authoritative surveys and specialized contributions dealing with techniques, problems, products, and possibilities in the broad areas of LASER expanding applications.
Representatives from 30 countries from all the Continents raised the number of participants envolved to 450, and a submission of 180 contributions. From those proceedings were published from camera-ready manuscripts supplied by authors.
The proceedings are of course, the result of considerable efforts by authors for which they are cordially thanked and acknowledged.

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LASER TECHNOLOGIES IN INDUSTRY

6-7-8 June 1988 — PORTO — PORTUGAL

The editors and the conference chairman would like to register profuse thanks expressly to the Organizations and Societies that lent the indispensable financial assistance and to other Institutions that provided complementary support.

The organizers would also like to express their deepest appreciation to the Conference Committee members and session Chairs who have so generously given of their time and advise to make this Conference possible.

The invaluable help of the staff working with the organizing committee is gratefully acknowledge, in particular, for their tireless efforts and assistance in memorable stimulating manner.

The editors are also indebted to Mrs. June Thompson and all of the SPIE team that across the Atlantic devoted so much work with professionalism and enthusiasm to the Conference and publication of the proceedings.

This conference would not be possible without the dedicated contribution of the so many volunteers in such a captivating friendly atmosphere.

The Editors and Organizers while attempting to bring the most relevant material presented to the attention and use of others interested in the field of LASER APPLICATIONS in INDUSTRY were driven by the irresistible impetus of stimulating the potentially so many yet hidden Archimedes that will shout foreseeable "Eureka" for the newcoming LASER applications.

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Porto, 1988

(1) D. Kales, "1988 Laser Economic Review and Outlook" Laser Focus (January 1988), 88-94

(2) O.D.D. Soares, M. Perez-Amor, Applied Laser Tooling, Martinus Nijhoff, Dordrecht (1987)

LASER TECHNOLOGIES in INDUSTRY is Supported by the Commission of the European Communities under the plan for transnational development of supporting infrastructure for innovation and technology transfer.

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SPIE - The International Society for Optical Engineering
P.O. Box 10 - Bellingham - Washington 98227 - U.S.A.

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Praça das Industrias, 1399 Lisboa Codex - Portugal

The Editors and Organizers wish to thank all the sponsors and co-sponsors that help in the various forms in the preparation and achievement of the LASER TECHNOLOGIES in INDUSTRY conference.

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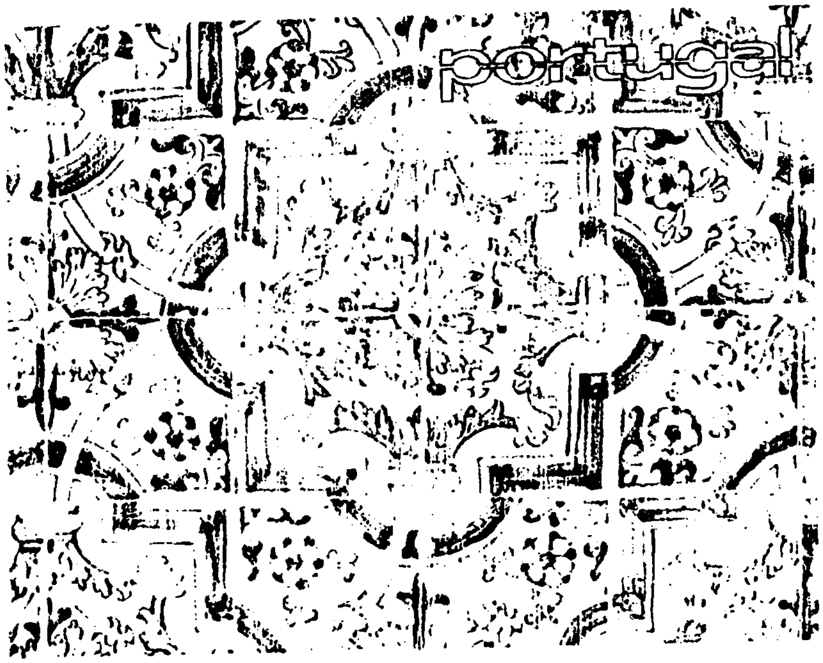

PROGRAMME

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SESSIONS, WORKSHOPS & EXHIBITION

Time				
	SUNDAY (JUNE 5)			
(17H00)	OPENING SESSION (room A)			
	General (room A)	Optical Metrology (room B)	Laser Sensing & Optical Metrology (Continuation) (room C)	Laser Processing (room D)
	MONDAY (JUNE 6)			
(8H30)	KEY NOTE ADDRESS (room A)			
(9H30)	General Overview (1 A)	Holographic Interf. (1 B)	Optical Sensors (1 C)	Applic. to Robotics and Automation (1 D)
			(13H30)	(13H30)
		(14H30)	Laser Tech. Char. Particle Matter in Industry (2 C)	Laser Cutting (2 D)
(16H30)	Further Laser Applications (2 A)	Holography in Dynamical Phenomena & ESPI (2 B)		
(17H30)	POSTER SESSION MP			
	TUESDAY (JUNE 7)			
(8H30)	PLENARY SESSION (room A)			
(9H30)	Continuation (2 A)	Continuation (2 B)	Continuation (2 C)	Continuation (2 D)
			(13H30)	
		(14H00)	Laser-Doppler Velocimetry (3 C)	
		Computer Aided Holography (3 B)		
(17H30)	POSTER SESSION TP			
	WEDNESDAY (JUNE 8)			
(8H30)	PLENARY SESSION (room A)			
(9H30)	Continuation (2 A)	Continuation (3 B)	Holographic Optical Elements (4 C)	Laser Materials Processing (3 D)
		(11H00)		
		Laser Surface Inspection (4 B)	(13H30)	
	(14H00)		Moiré Holography (5 C)	(14H30)
	Lasers in Medicine (3 A)			LCVD (4 D)
(17H30)	THURSDAY (JUNE 9)			
(8H30)	WORKSHOP: Laser in Medicine			
(13H30)	WORKSHOP: Laser Technologies in Ocean Sciences			

EXHIBITION (Room E)

Open every day, 6-8 June

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CONFERENCE OFFICIAL OPENING

The official opening session was held on sunday, 5 June at the conference site under the auspices of the Rectorate of the University of Porto from 17H00 to 19H00.

NOTES: * invited paper

CONFERENCE PLENARY SESSIONS

Three plenary sessions were scheduled.They provided a means of integration over the diverse topics to be dealt.

CONFERENCE SESSIONS

MONDAY 6th JUNE

Plenary Session - KEYNOTE ADDRESS
Chairmen: O. Soares, Lab. Fisica, Fac. Ciencias, Univ. Porto, Portugal
A. Sona, CISE, Milano, Italy

MA1,2P - Laser Applications in Modern Industries* ---------- 8H30-9H30
A.J. DeMaria, United Technologies Research Center, USA

SESSION 1A - General Overviews
Chairmen: U.Kotte, KFA Programmgrouppe Tech. U. Geisselschafft, FRG
R.P. Main, Roger P. Main Consulting, Darmstad, FRG
K. Geissler, CERN, Geneve, Switzerland

MA3 - Important Factors for Resource Allocation in Applied Research and Development* ---------- 9H30-10H00
U. Kotte, KFA Programmgrouppe Technik U. Geisselschafft, Julish, FRG

MA4 - Integration and Convergence of Technologies: a Challenge for Europe ---------- 10H30-11H00
W. Wobbe, CEC, DG XII - A-1, Brussels, Belgium

MA5,6 - Optical and Laser Technologies - The Next 25 Years ---------- 11H00-11H30
R.P. Main, Roger P. Main Consulting, Darmstad, FRG

MA6a - CNR's Special Project on Electro-optics Technologies (TEO) ---------- 12H00-12H30
S. Martellucci, Univ. di Roma "Tar Vergata", Italy

MA7 - Entrepreneurial Aspects for Industrial Applications of Laser Technologies ---------- 13H30-14H00
A. Silva Teixeira, BFN, Lisboa Portugal

MA8 - Eureka: High Power Solid State Laser European project ---------- 14H00-14H30
Alain Diard, Quantel S.A., Les Ulis, France

MA9 - Optoelectronique Laser - Realization et Success ---------- 14H30-15H00
C. Liegeois, X'IAL, Strasbourg, France

MA10 - Strategy on Laser Technologies Uses in a Research Laboratory*---------- 15H30-16H00
K. Geissler, CERN, Geneve, Switzerland

MA11 - Atelier Laser - une reussite ---------- 16H00-16H30
G. Mathiew, ARES, Beauchamp, France

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SESSION 2A - Further Laser Applications
Chairmen: M. Calvo, Univ. Compultense, Fac. Ciencias Fisicas, Spain
P. Persephonis, Univ. Patras, Greece
J.M. Zavada, USARDSG, London, U.K.

MA12 - Laser Interferometer for Optical Testing using Non-linear Optical Effect* --------------- 16H30-17H00
C.P. Grover, National Research Council, Canada

SESSION 1B - Holographic Interferometry
Chairmen: A. Reis, Univ. of Coimbra, Portugal
C. Shakher, BHEL, Vikasnagar, India
C.P. Grover, National Research Council, Canada

MB3 - Thermal Rectifying Walls* --- 9H30-10H00
A. Reis, Univ. Coimbra, Portugal

MB4 - An Experimental Analysis of Natural Convection in a One Sided Heated Vertical Channel with Holographic Interferometry -- 10H30-11H00
I.Y. Uralcan, O. F. Genceli, Fac. of Mech. Eng., Istanbul Tech. Univ., Turkey

MB5 - Holographic Evaluation of Stiffener Configuration in Water Boxes of an Industrial Heat Exchanger -- 11H00-11H30
C. Shakher, A.D. Baone and G. Venkata Rao, BHEL, Vikasnagar, India

MB6 - Digital Phase Stepping Speckle Interferometry -- 11H30-12H00
A.A.M. Maas and H.A. Vrooman, Technological University Delf, The Netherlands

MB7 - Tomographic Representation of Temperature Profiles in a Convective Heat Flow by High Resolution Holographic Interferometry -- 13H30-14H00
D. Vukicevic, Inst. Physics Univ. Zagreb
J. Woisetschlager, H. Philipp, T. Neger, H. Jager, Tech. Univ. Graz

MB8 - A New Full-Field Phase Shift Method for Holographic Interferogram ---------------------- 14H00-14H30
Y.Y. Hung, X. Zhang, F.S. Chau and J.T. Ke, Oakland Univ., USA

SESSION 2B - Holography in Dynamical Phenomena & ESPI
Chairmen: P. Smigielsky, ISL, Saint-Louis, France
O. Løkberg, Technical Univ. of Trondheim, Norway

MB9 - Hologrametric Dynamic Techniques* -- 14H30-15H00
P. Smigielsky, ISL, Saint-Louis, France

MB10 - Industrial Applications of ESPI* -- 15H30-16H00
O. Løkberg, Technical Univ. of Trondheim, Norway

MB11 - Some New Techniques with Digital Speckle Pattern Interferometry (DSP ------------------- 16H00-16H30
R.S. Sirohi, A.R. Ganesan, M.P. Kothiyal, Indian Inst. Tech., India

MB12 - In-Situ Investigations of Deformations of Natural Stones by Electronic Speckle Pattern Interferometry (ESPI) ----- --- 16H30-17H00
G. Gulker, K. Hinsch, C. Holscher, A. Kramer and H. Neunaber
University of Oldenburg, FRG

SESSION 1C - Optical Sensors
Chairman: G.C. Righini, IROE, Firenze, Italy
B. Culshaw, Univ. Strathclyde, U.K.

MC3 - Integrated Optical Sensors - State-of-the-Art and Perspectives* ------------------------- 9H30-10H00
G.C. Righini, IROE, Firenze, Italy and A. Naumaan, USA

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MC4 - Laser and Optical Fiber Sensors: an overview* ---------- 10H30-11H00
M. Brenci, G. Conforti

MC5 - Fiber Optic Sensors - Practice and Possibilities ---------- 11H00-11H30
B. Culshaw, Univ. Strathclyde, U.K.

MC6 - Wide-range Pressure Sensors Based on Incoherent Diffraction Moiré Effect ---------- 11H30-12H00
J. Ebbeni and H. Sandrowicz, Univ. Libre Bruxelles, Belgium

SESSION 2C - Laser Technologies for Characterization of Particle Matter in Industry
Chairmen: B. Scarlett, Delft Univ. of Technology, The Netherlands
M. Rebola, University of Coimbra, Portugal
M. Graça Rasteiro, University of Coimbra, Portugal

MC7,8 - Laser for Particle Size Measurement Hardware and Software* ---------- 13H30-14H30
B. Scarlett, Delft Univ. of Technology, The Netherlands

MC9 - Measurement of the Velocity and Size Distribution of Droplets and of their Statistical Correlation ---------- 14H30-15H00
H. Burnage, Univ. Louis Pasteur, Strasbourg, France

MC10 - A Phase-Doppler Instrument for Optical Particle Sizing ---------- 15H30-16H00
M. Saffman, Dantec Elektronik, Denmark

MC11 - Particle Size and Velocity Measurement of Flow of Opaque or Non-transparent Spherical Particles by Laser-Doppler Anemometry: Problems of Practical Application ---------- 16H00-16H30
K. Bauckhage, U. Fritsching, J. Heuermann, G. Schulte
University of Bremen, FRG

MC12 - Studies of Flocculation/Deflocculation of Kaolin Suspensions using LDS ---------- 16H30-17H00
M. Rebola, G. Rasteiro, F. Pita, Univ. Coimbra, Portugal

SESSION 1D - Applications to Robotics and Automation
Chairman: W.M. Steen, Mech. Eng. Dept., The University, Liverpool, U.K.
M. Perez- Amor, ETS, University of Santiago, Vigo, Spain

MD4,5 - Some Viewpoints on Laser Automation and Processing Quality Control* ---------- 10H30-11H30
W.M. Steen, L.Li, Mech. Eng. Dept., The University, Liverpool, U.K.

MD6 - Robot Guided Laser for Three-Dimensional Laser Processing ---------- 11H30-12H00
R.D. Schraft, G. Hardock and M. Konig, IPA, Stuttgart, FRG

SESSION 2D - Laser Cutting
Chairmen: F. Olsen, Technical Univ. of Denmark, Denmark
M.R. Teixeira, LNETI, Lisboa, Portugal
D. Appelt, EFACEC, Portugal

MD7 - Laser Cutting* ---------- 13H30-14H00
F. Olsen, Technical Univ. of Denmark, Denmark

MD8 - Thermal Modelisation of Laser Cutting Process ---------- 14H00-14H30
S.F. Yuan, M. Querry and C. Bedrin, Lab d'Etudes Proc Fab, France

MD9 - Heat Conduction and Mass Transfer in Laser Cutting ---------- 14H30-15H00
D. Schuocker, Technische Univ. Wien, Austria

MD10 - The Application of CO2 LASER to Precise Cutting in Japan ---------- 15H00-16H30
M. Kanaoka, Mitsubishi Electronic Co, Nagoya, Japan

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MP - POSTER SESSION (17H00-19H00)

MP1 - Constructions of Holographic Mirrors in Dichromated Gelatin
A.A. Andrade and J.M. Rebordão, LNETI, Lisboa, Portugal

MP2 - Determination of Pressure Changes in Fluids by means of Gas Bubbles
H.-St. Buchkremer and C.G. Stojanoff, RWTH Aachen, FRG

MP3 - Laser Speckle Size and Temporal Transfer Function in Human Vision
J. Peréz-Carpinell and V. Climent, Fac. Fisica, Univ. Valencia, Spain

MP4 - Non Contact Measuring Machine
F.D. Carvalho, P. Sebastião and B. Henriques, LNETI, Lisboa, Portugal

MP5 - Automatic Machine for Spin Testing
F.D. Carvalho, F.C. Rodrigues, C.P. Pais, LNETI, Lisboa, Portugal
and R. Prina, INDEP, Lisboa, Portugal

MP6 - High Precision Measurement Equipment
F.D. Carvalho, J.M. Rebordão, F.C. Rodrigues, LNETI, Lisboa, Portugal
and J. Daeta, PRECIOPTIC, Matosinhos, Portugal

MP7 - Laser Scanner for Automatic Storage
F.D. Carvalho, B.A. Correia, J.M. Rebordão
and F.C. Rodrigues, LNETI, Lisboa, Portugal

MP8 - The Application of Laser Beams to Absolute Photodetector Calibration
A. Corróns, J. Campos, A. Pons and P. Corredera Inst. de Optica "Daza de Valdes", Madrid, Spain

MP9 - A Laser Rangefinder for Hot Surface Profiling Measurements
K. Maatta, J. Kostamovaara, University of Oulu, Finland
R. Myllyla, Technical Research Centre of Finland

MP10 - Optical Processing of Military Targets
F. Dubois, U.L.B., Belgium
I. Lacroix and E. Schweicher, ERM, Brussels, Belgium

MP11 - Projection Fringes Microscope
J.C.A. Fernandes, O.D.D. Soares, Fac. Ciencias Univ. Porto, Portugal

MP12 - Construção de um Analisador de Particulas
C.A. Couto, M.J.C. Romero, Univ. Minho, Portugal
J.A. Fernandes, Fac. Ciencias Univ. Porto, Portugal

MP13 - Fast Holographic Camera for Industrial and Scientific Applications
M. Delepierre, MICRAUDEL, France

MP14 - Spatially Resolved Presentation of Convective Heat Transport by Multidirectional Holographic Interferometry
D. Vukicevic, Inst. Physics Univ. Zagreb
J. Woisetschlager, H. Philipp, T. Neger, H. Jager, Tech. Univ. Graz

MP15 - Laser Excited Vapor Phase Synthesis of Submicron Powders from Halogenated Silanes
R.A. Bauer, P.J. van den Put, B. Scarlett and J. Schoonman
Univ. of Technology, Delft, The Netherlands

MP16 - Laser Surface Treatment of a X42 Cr13 (Din) Toll Steel
R. Vilar, R.M. Miranda and A.S. Oliveira, IST, Lisboa, Portugal

MP17 - Laser Welding of AISI 301 Stainless Steel Thin Sheet
R. Vilar and Rosa M. Miranda, IST, Lisboa, Portugal

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LASER TECHNOLOGIES IN INDUSTRY

6-7 8 June 1988 PORTO · PORTUGAL

TUESDAY 7th JUNE 1988

Plenary Session
Chairmen: O.D.D. Soares, Lab Fisica, Fac. Ciencias, Univ. Porto, Portugal
F.M.V.P. Morais, Centro de Fisica, Fac Ciencias, Univ Porto, Portugal

IA1,2P - Overview of Optical Methods in Metrology* ---------- 8H30-9H30
J. Ebbeni, Univ. Libre Bruxelles, Belgium

SESSION 2A - Further Laser Applications (Cont.)

IA3 - Modern Optical Coating Technologies for Low Loss Dielectric Films ---------- 9H30-10H00
H.K. Pulker, Balzers AG, Liechtenstein

IA6 - Open Field Phase Measuremnt Telemeter for Orbital Rendez-vous ---------- 11H30-12H00
M. Faup, CNES, Toulouse, France
F. Hullein, SERCEL, Carquefou, France

IA7 - Design of Mesfet Optical Amplifier ---------- 13H30-14H00
M.N. Armenise, A. G. Perri, Dept. Elettrotecnia ed Elettronica, Italy

IA8 - Coupling Efficiency in a Holocoupler-Optical Fiber System ---------- 14H00-14H30
M.I. Calvo and L. de Pedraza, Univ. Compultense, Spain

IA9 - Ion-Beam Processing Multilayer Semiconductor Structures ---------- 14H30-15H00
J.M. Zavada, USARDSG, London, U.K.
R.G. Wilson, Hughes Res. Lab., Malibu, USA
and J. Comas, Nat. Bureau of Standards, USA

IA10 - Feedback Induced Non-monotonic Behavior of the Differential Quantum Efficiency with the Current, in InGaAsP Injection Lasers ---------- 15H30-16H00
G. Chiaretti, G. Sacchi, Reverdito, IALTEL SIT, Milano, Italy
F. Brivio, M. Milani, Dipt. di Fisica dell'Univ., Milano, Italy

IA11 - Calculation of the Ambipolar Diffusion Coefficient through Lasing Action in Gases ---------- 16H00-16H30
P. Persephonis, R. Giannetas and R. Rigopoulos, Univ. Patras, Greece

IA12 - Off-axis Elliptical Zone Plate for Nonsymmetric Fourier Transforming ---------- 16H30-17H00
S. Barà and C. Gomez-Reino, Univ. Santiago de Compostela, Spain

SESSION 2B - Holography in Dynamical Phenomena & ESPI(Cont.)

IB3 - Application of Holography and ESPI Techniques to Earthquake Prediction ---------- 9H30-10H00
S. Takemoto, DPRI, Kyoto University, Japan
T. Tsuboi, Fac. of Science, Kyoto Sangyo Univ., Japan

IB4 - Interferometric Studies of Very Hot Objects by Use of TV-Holography (ESPI) ---------- 10H30-11H00
J.T. Malmo SINTEF, Trondheim, Norway

IB5 - Measuring Rotating Component In-Plane Strain Using Conventional Pulsed ESPI and Optical Fibers ---------- 11H00-11H30
R.W.T. Preater, The City University, London, U.K.

IB6 - Three Dimensional Vibration Analysis Using Electronic Speckle Pattern Interferometry ---------- 11H30-12H00
M. C. Shellabear and J. Tyrer, Loughborough University of Technology, U.K.

IB7 - Developments in ESPI for Automotive Vibration Analysis ---------- 13H30-14H00
J.C. Davies and C.H. Buckberry, Austin Rover, U.K.

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SESSION 3B - Computer Aidded Holography
Chairmen: J. Ebbeni, Univ. Libre Bruxelles, Belgium
P. Pryputniewicz, Worcester Polytechnic Institut, USA

TB8 - Computerized Holographic Techniques for Quantitative Evaluation* ------------------------ 14H00-14H30
C. Liegeois, X'IAL, Strasbourg, France

TB9 - On-line Fringe Analysis by Real-time Phase-shift-processing ---------------------------- 14H30-15H00
B. Breuckmann, Optotech, FRG

TB10 - Automatic Fringe Analysis -- 15H30-16H00
Rottenkolber, Rottenkolber Holo-System GmbH, FRG

TB11 - Numerical Processing of Holographic Data -- 16H00-16H30
H. Steinbichler, Labor DR Steinbichler, Bavaria, R.F.G.

TB12 - Software Techniques for the Analysis of Contour Maps of Manufacturing Components -------- 16H30-17H00
D.R. Burton and M.J. Lalor Liverpool Polytechnic, U.K.

SESSION 2C - Laser Tech. for Charact. of Particles Matter in Industry (Cont.)

TC3 - Effect of Shape, Structure & Texture on the Accuracy of Size Characterization
of Fineparticles by Light Scattering --- 9H30-10H00
B.H. Kaye and R. Trottier, Laurentian Univ., Ontario

TC4 - Using Fast-Fourier-Transform (FFT) for the Phase-Doppler-difference analysis
of Powder Metal Sprays -- 10H30-11H00
K. Bauckhage, A. Schone, Th. Wriedt, Univ. Bremen, FRG

TC6 - On-line Measurement of Crystal Size and Shape Using Combined Optical Techniques --------- 11H30-12H00
A. Boxman and B. Scarlett, Delft, Univ. Technology, The Netherlands

SESSION 3C - Laser-Doppler Velocimetry (LDV)
Chairmen: M. Malafaya-Baptista, Fac. Eng., Univ. Porto, Portugal

TC7 - Laser Doppler Anemometry in Hydraulic Research -- 13H30-14H00
A.A. Ribeiro, M.F. Proença, Fac. Eng., Univ. Porto, Portugal

TC8 - Laser-Doppler Measurements of Impinging Jets -- 14H00-14H30
J.M.M. Barata, D.F.G. Durão and M.V. Heitor
IST, Lisboa, Portugal

TC9 - A Cost-Effective LDV System --- 14H30-15H00
C.A. Hobson and M.J. Lalor, Liverpool Polytechnic, U.K.

TC10 - Laser Diagnostics of the Flow in Industrial Burners ------------------------------------ 15H30-16H00
D.F.G. Durão and M.V. Heitor and A.L.N. Moreira
IST, Lisboa, Portugal

TC11 - Laser Doppler Measurement of Fan-belt Slippage --- 16H00-16H30
Finn Mengel, DANTEC Electronik, Denmark

TC12 - Strengths and Limitations of the Phase Doppler Technique for Simultaneous
Measurements of Particle Velocity and Size -- 16H30-17H00
D.M. Livesley, UKAEA Harwell Lab., U.K.

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SESSION 2D - Laser Cutting (Cont.)

TD3 - CO2 Laser Cutting of Titanium Alloys -- 9H30-10H00
J. Powell, Laser Expertise lda, Nottingham, U.K.
M. Jezioro, I.A. Menzies, Loughborough Univ. of Tech., U.K.
P.F. Scheyvearts, Coherent Beneral GmbH, Munich, FRG

ID4 - Recorte e Gravação de Materiais com Laser de CO2 -- 10H30-11H00
D. Appelt and A. Cunha, EFACEC, Portugal

ID5 - Marble Cutting by Laser -- 11H00-11H30
M. Pires, A. Ferreira, H. Ribeiro, M. Teixeira, LNETI, Portugal

ID7 - Trends in Heavy Section Laser Cutting -- 13H30-14H00
S. Sepold, BIAS, Bremen, FRG

TD8 - Cutting with Ng-Yag Laser -- 14H00-14H30
P.K. Affolter, Lasag, Switzerland

ID10 - Photolitogrphic Masks for Integrated Optics Circuits Fabricated with an
Ar+ Laser System -- 15H30-16H00
P. Boffi, O. de Pascale, C. Esposito, M. Gaudio, A.M. Losacco, M. Vilnio
Centro laser, Bari, Italy

TD11 - Laser Direct-Writing of Gratings for Integrated Optics -- 16H00-16H30
G. Assanto, CRES, Monreale, Italy
C. Cali and S. Riva-Sanseverino, DIE, Univ. Palermo, Italy

IP - POSTER SESSION (17H00-19H00)

IP1 - SIIPUL - A Simulating System for Firing Instruction Using Laser.
J.C. Freitas, F.C. Rodrigues, LNETI, Portugal
V.M. Silvestre, EID, Portugal; R. D. Prina, INDEP, Portugal
and Mateus da Silva, EML, Portugal

IP2 - Trends in Moiré Holography
A.V.S. Lage and O.D.D. Soares, Univ. Porto, Portugal

IP3 - On the Use of an Optomechanical Sensing Head in Time-of-Flight Laser Rangefinding
M. Koskinen, R. Ahola, J. Kostamovaara and R. Myllyla, Finland

IP4 - NDT Holographic Testing of Tubes and Joints
F.M.V. Pires de Morais, O.D.D. Soares, Centro Fisica, Univ. Porto, Portugal

IP5 - Laser Scanning in Surface
A.O.S. Gomes, O.D.D. Soares, Centro Fisica, Univ. Porto, Portugal

IP6 - Sistema de Encaminhamento de Feixe para Laser de CO2
D. Appelt and A. Cunha, EFACEC, Portugal

TP7 - Energy Distribution Analysis of High Power Laser Beam From Spots on Paper
J. Merlin, C. Oliveira, J. Dietz, INSA lyon, GEMPPM-CALFETMAT, France

TP8 - Characterization of Real Laser Beam Profiles with Few Parameters for Metallurgical Applications
J. Merlin, J. Dietz, C. Oliveira, INSA lyon, GEMPPM-CALFETMAT, France

TP9 - Laser Beam Shaping by Computer Made Holograms
S. Sahnoune, M. Torzynski and P. Meyrueis, Lab. Syst. Photoniques, France

TP10 - Development of Stabilized CO2 Lasers
N. Silvestre, J. Lemos and M. Ribau Teixeira, LNETI/DEE, Lisboa, Portugal

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TP11 - On the Influence of Gas Flow in Electrical Excited CO2 Lasers
N. Silvestre and M. Ribau Teixeira, LNETI/DEE, Lisboa, Portugal

TP12 - Application of Holographic Interferometry to a Fracture Mechanics Problem
M.A.P. Vaz, A.L.V.S. Lage, J.F. S. Gomes, Fac. Eng. Univ. Porto, Portugal

TP13 - Use of TALBOT Interferometry to Measure the Focal Length of Refractive/Reflective Imaging Systems
L.M. Bernardo and O.D.D. Soares, Centro de Fisica Univ. Porto, Portugal

TP14 - Optical Implementation of a Neural Network Using Spatial Light Modulator: Discussion of Properties and Performance
M. Torzynski, Ecole Nationale Superieur de Physique, France

TP15 - Interferometric Alignment by Circular Zone Plate
V. Moreno, M.V. Perez, S. Bara and C. Gomez-Reino
Lab. Optica, Fac. Fisica, Univ. Santiago, Spain

TP16 - Behavior of Austempered Ductile Irons (ADI) Subjected to Laser Surface Melting
D.L. Jones, I. Fagoaga. J.F. Liceaga, INASMET, Non-Metallic Mat. Group, Spain
P. Sanz, K. Jasnowski, Centro Laser de Navarra, Spain

TP17 - Fiber Optic Interferometric Sensor: Simultaneous Measurement of Temperature and Pressure
H. Bellil, P. Meyreuis, LSP ENSPS and A. Chakari, Societe Filergie, France

TP18 - Three-Dimensional Displacements by Sandwich Holographic Interferometry
L. Wang, J. Ke
Holographic Lab., Zhengzhou Institute of Technology, Zhengzhou, People's Republic of China

WEDNESDAY 8th JUNE

Plenary Session
Chairmen: O.D.D. Soares, Lab Fisica, Fac. Ciencias, Univ. Porto, Portugal
L.M. Bernardo, Lab Fisica, Fac. Ciencias, Univ. Porto, Portugal
F.M.V.P. Morais, Centro de Fisica, Fac Ciencias, Univ Porto, Portugal

WA1,2P - Lasers for Industrial Material Processing * ---------- 8H30-9H30
A. Sona, CISE, Milano, Italy

SESSION 2A - Further Laser Applications (Cont.)

WA3 - Spinodal Determination in Polymer Oligomer Mixture in Solution by Laser Light Scattering ---------- 9H30-10H00
C.C. Cesteros, Univ. Pais Vasco, Bilbao, Spain

WA4 - Rapid Determination of the Wobbe-Index of Natural Gas ---------- 10H30-11H00
O. Florisson, N.V. Nederlandse Gasunie, The Netherlands

WA5 - Interaction Parameters of Polymer-Polymer Systems by Laser Light Scattering ---------- 11H00-11H30
I. Katime, N. Gonzalez, M. Rodrigues and J.R. Quintana
Fac. Ciencias, Univ. del Pais Basco, Bilbao, Spain

WA6 - All-Optical Wide-Area Remote Sensing of Dispersal of Unsafety Gases by Near-Infrared Absorption Based on Low-Loss Optical Fiber Network* ---------- 11H30-12H00
Humio Inaba, Tohoku Univ., Sendai, Japan

WA7 - In-Situ Measurement of Amonia with 13CO2 Waveguide Laser System ---------- 13H30-14H00
H. Neckel and J. Wolfrum, Ruprecht-Karls-Univ., Heidelberg, FRG

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SESSION 3A - Lasers in Medicine
Chairmen: V. Russo (Univ. Salerno - Salerno - Italy)
G. von Bally (Munster Univ. - Munster - FRG)
H. Podbielska (Tech. Univ. Wroclaw - Wroclaw - Poland)

WA8 - Optical Detection of Bacteria using a Fluorescent Immunoassay -------------------------- 14H00-14H30
R.W. Wygant, S.P. Almeida, H.D. Pierson, J.C. Hedrich
Virginia Polytechnic Inst., Dept. Physics, USA
G.B. Churchill and H.P. Groger, SPA International Incorporated, USA

WA9 - Laser Systems for Bio-medical Applications* -- 14H30-15H30
V. Russo, Univ. Salermo, 84100 Salermo, ITALY

WA10 - Orthopaedic Devices Examined By Holographic Interferometry ----------------------------- 15H30-16H00
Halina Podbielska and H. Kasprzak, Tech. Univ. Wroclaw, Poland
G. von Bally, Munster Univ., Munster, FRG

WA11 - Holographic Endoscopy* -- 16H00-16H30
G. von Bally, Munster Univ., Munster, FRG

SESSION 3B - Computer Aided Holography (Cont.)

WB3 - Interferometric Techniques, Data Extraction and Quantitative Analysis* ------------------ 9H30-10H00
K. Pryputniewicz, Worcester Polytechnic Institut, USA

WB4 - NDT of Composite Materials, State-of-the-Art* -- 10H30-11H00
J. Ebbeni, Univ. Libre Bruxelles, Belgium

SESSION 4B - Laser Surface Inspection
Chairmen: S.P. Almeida, Virginia Polytechnic Inst., Dept. Physics, USA
O.D.D. Soares, Centro de Fisica, Univ. Porto, Portugal

WB5 - Surface Quality Assessment by Laser Technique ---- ------------------------------------- 11H00-11H30
M. Bertolotti, L. Fabbri and C. Sibilia, Univ. Roma, Italy

WB6 - Laser Scanning Microscope -- 11H30-12H00
T. Wilson, Dept. Eng. Science, Univ. Oxford, U.K.

WB7 - Automatic Surface Analysis with Fringe Projection* ------------------------------------- 13H30-14H00
S.P. Almeida, R.W.Wygant, Virginia Polytechnic Institute, USA
and O.D.D. Soares, Lab. Fisica, Fac. Ciencias, Univ. Porto, Portugal

WB8 - Surface Inspection of Laser Burnt Alloy Via Three Dimensional Computer
Color Contouring --- 14H00-14H30
R.W. Wygant, S.P. Almeida, Virginia Polytech. Inst. & State Univ., USA
R.J. Churchill, J.M. Glass and H.P. Groger, SPA Int. Incorporated, USA

WB9 - Surface Roughness Measurement by Speckle Processing in a Defocused Plane --------------- 14H30-15H00
N. Russo, N. Bolognini, E. Sicre, M. Garavaglia, CIOP, Argentina

WB10 - Mapping of Textile Surface Relief --- 15H30-16H00
M.F.P.C.M. Costa, J.M.B. Almeida, Lab. Fisica Univ. Minho, Portugal

WB11 - Eddy Current Non-destructive Evaluation of Laser Glazed Metallic Surfaces -------------- 16H00-16H30
R.J. Churchill, J.M. Glass, H.P. Groger and S.S. Lane, SPA International Incorporated, USA

WB12 - Physical Backgrounds of Laser Inspection of Rough Surfaces* ---------------------------- 16H30-17H00
H.A. Ferwerda, Dept. Appl. Physics, Univ. Groningen, The Netherlands

WB13 - An Application of Optical Surface Assessment to Engine Preparat'on Techniques ----------- 17H00-17H30
K. J. Stout, University of Birmingham, U.K.

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SESSION 4C - Holographic Optical Elements
Chairmen: C. Liegeois, X'IAL, Strasbourg, France
C. Gomez-Reino, Lab. Optica, Fac. Fisica, Univ. Santiago, Spain

WC3 - Visible and Near-Infrared HOE ---------- 9H30-10H00
C. Liegeois, X'IAL, Strasbourg, France

WC4 - Silver Halide Sensitized Gelatin as a Holographic Storage Medium ---------- 10H30-11H00
A. Fimia, I. Pascual and A. Belèndez
Dpto. Interuniversitario de Optica, Alicante, Spain

WC5 - Laser Interferometric Method for the Measurement of Film Thickness, Using Holographic Optical Elements ---------- 11H00-11H30
K. Matsuda and M. Namiki, Mechanical Eng. Lab, Japan

WC6 - Development and Manufacturing of an Integrated Miniaturized Holographic Lased-Doppler Optics ---------- 11H30-12H00
G.C. Stojanoff, H.D. Tholl, F. Botter and R. Holler, RWTH AACHEN, FRG

SESSION 5C - Moirè Holography
Chairmen: J. Ebbeni, Univ. Libre Bruxelles, Belgium

WC8 - Improvements in Moirè-Holographic Gratings for Structural Analysis ---------- 14H00-14H30
F. Ginesu and R. Rossi, Depto Ing. Meccanica, Cagliari, Italy

SESSION 3D - Laser Materials Processing
Chairmen: A. Sona, CISE, Milano, Italy
J. Mazunder, Illinois Univ. USA
R. Vilar, IST, Lisboa, Portugal

WD3 - Thermography of Laser Metal-Sheet Welding ---------- 9H30-10H00
O. Valdez, P. Bilmes and A. Gonzalez, LIMF, Univ. La Plata, Argentina
E.G. Lluesma, CIOP-CIC, La Plata, Argentina

WD4 - Stainless Steel Cladding of Structural Steels by CO_2 Laser Welding Techniques ---------- 10H30-11H00
A. Ludovico, Univ. di Bari, Italy
G. Daurelio, Centro-Laser, Bari, Italy

WD5 - Metal-Silicon Reaction with Laser Pulses and Electron Beams ---------- 11H00-11H30
A. Luches, Univ. Lecce, Italy

WD6 - Microstructure and Oxidation Properties of Laser Clad Ni70 Al20 Cr7 Hf3 Alloys with Extended Solid Solution of Hf* ---------- 11H30-12H00
J. Mazunder, S. Sircar, C. Ribaudo and A. Kar, Univ. Illinois, USA

WD6a - Behavior of Austempered Ductile Irons (ADI) Subjected to Laser Surface Melting ---------- 12H00-12H30
D.L. Jones, I. Fagoaga, J.F. Liceaga, INASMET, Spain
P. Sanz, K. Jasnowski, Centro Laser de Navarra, Spain

WD7 - Laser Surface Engineering of Tool Materials ---------- 13H30-14H00
A. Bloyce, T. Bell, I.M. Hancock, University of Birmingham, U.K.

WD8 - Aluminium Reflectance under Excimer Laser Irradiation ---------- 14H00-14H30
A. Anneda, A. Mura, F. Raga and M. Cappai, Univ. Cagliari, Italy

WD9 - Automatic Seam Flowing* ---------- 14H30-15H00
J. Lucas, Liverpool University, U.K.

WD10 - New Ceramic Coatings Prepared by Laser Processing for High Temperature Corrosion Protection ---------- 15H30-16H00
M.J. Bennett, Materials Development Division, Harwell Laboratory, U.K.

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SESSION 4D - Laser Chemical Vapor Deposition (LCVD)
Chairmen: M. Perez-Amor, EST Ing. Industriales, Spain
W. M. Steen, Imperial College, London, U.K.

WD11 - Application of LCVD: Metallurgic, Micro-electronics and Micro-Optics* ------------------ 16H00-16H30
M. Perez-Amor and B. Leon-Fong, EST Ing. Industriales, Spain

WD12 - Laser-Induced Formation of SiO2-Layers for Microelectronics ---------------------------- 16H30-17H00
H. Sigmund, Fraunhofer Inst. fuer Festtkoerpertechnologie, FRG

WORKSHOPS

The conference was followed by two workshops held at HOTEL PORTO ATLANTICO in the 9 June.

WORKSHOP - LASERS in MEDICINE

This workshop has been organized by Professor Nuno Grande the Dean of the Instituto de Ciências Biomédicas Abel Salazar in the morning of Thursday 9 June.

WORKSHOP - LASERS in OCEAN SCIENCES

This workshop has been conducted by Professor S.P. Almeida of the Virginia Polytechnic and State University in the afternoon of Thursday 9 June.

LIST OF EXHIBITORS

EQUIPMENT

- LNETI
- SIEMENS: INTERATOM
- EFACEC
- M.T. BRANDAO: COHERENT U.K.; COHERENT COMPONENTS; GENERAL SCANNING
- LUFA: MELLES GRIOT
- MECOPIL: MICRO-CONTROLE
- SOC. SKF: JACOB
- MOLLER-WEDEL
- Cia NACIONAL DE OXIGENIO
- CABELTE

SCIENTIFIC BOOKS & JOURNALS

- KLUWER PUBL.
- OXFORD UNIV. PRESS
- IOP PUBL.

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LASER TECHNOLOGIES IN INDUSTRY

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LASER TECHNOLOGIES IN INDUSTRY

6-7-8 June 1988 — PORTO — PORTUGAL

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LASER TECHNOLOGIES IN INDUSTRY

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SESSION CHAIRMEN

Plenary Session - KEYNOTE ADDRESS
Chairmen: O. Soares, Lab. Fisica, Fac. Ciencias, Univ. Porto, Portugal
A. Sona, CISE, Milano, Italy

SESSION 1A - *General Overviews*
Chairmen: U. Kote, KFA Programmgrouppe Technik U. Geisselschafft, Julish, FRG
R.P. Main, Roger P. Main Consulting, Darmstad, FRG
E. Geissler, CERN, Geneve, Switzerland

SESSION 2A - Further Laser Application
Chairmen: M. Calvo, Univ. Complutense, Fac. Ciencias Fisicas, Spain
P. Persephonis, Univ. Pratas, Greece
J.M. Zavada, USARDSG, London, U.K.

SESSION 3A - Lasers in Medicine
Chairmen: V. Russo, Univ. Salerno, Italy
G. von Bally, Munster Univ., FRG
H. Podbielska, Tech. Univ. Wroclaw, Poland

SESSION 1B - Holographic Interferometry
Chairmen: A. Reis, Univ. Coimbra, Portugal
C. Shakher, BHEL, Vikasnagar, India
C.P. Grover, National Research Council, Canada

SESSION 2B - Holography in Dynamical Phenomena & ESPI
Chairmen: P. Smigielsky, ISL, Saint-Louis, France
O. Lokberg, Technical Univ. of Trondheim, Norway

SESSION 3B - Computer Aided Holography
Chairmen: J. Ebbeni, Univ. Libre Bruxelles, Belgium
P. Pryputniewicz, Worcester Polytechnic Inst., USA

SESSION 4B - Laser Surface Inspection
Chairmen: S.P. Almeida, Virginia Polytechnic Inst., Dept. Physics, USA
M. Garavaglia, CIOP, Argentina

SESSION 1C - Optical Sensors
Chairmen: G.C. Righini, IROE, Firenze, Italy
B. Culshaw, Univ. Strathclyde, U.K.

SESSION 2C - Laser Technologies for Charact. of Particles Matter in Industry
Chairmen: B. Scarlett, Delft Univ. of Technology, The Netherlands
M. Rebola and M. Graça Rasteiro, Univ. Coimbra, Portugal

SESSION 3C - Laser-Doppler Velocimetry (LVD)
Chairmen: M. Matalaya-Baptista, Lab Hidraulica, Fac Engenharia, Univ. Porto, Portugal

SESSION 4C - Holographic Optical Elements
Chairmen: C. Liegeois, X'IAL, Strasbourg, France
L. Bernardo, Lab. Fisica, Fac. Ciencias, Univ. Porto, Portugal

SESSION 5C - Moirè Holography
Chairmen: J. Ebbeni, Univ. Libre Bruxelles, Belgium

SESSION 1D - Applications to Robotics and Automation
Chairmen: W.M. Steen, Mech. Eng. Dept., Univ. Liverpool, U.K.
L. Pera, CRF-FIAT, Turin, Italy

SESSION 2D - Laser Cutting
Chairmen: F. Olsen, Technical Univ. of Denmark, Denmark
M.R. Teixeira, LNETI, Lisboa, Portugal
D. Appelt, EFACEC, Portugal

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LASER TECHNOLOGIES IN INDUSTRY

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SESSION 3D - Laser Materials Processing
Chairmen: A. Sona, CISE, Milano, Italy
J. Mazunder, Illinois Univ., USA
R. Vilar, IST, Lisboa, Portugal

SESSION 4D - Laser Chemical Vapor Deposition (LCVD)
Chairmen: M. Perez-Amor, ESI Ing. Industriales, Spain
W.M. Steen, Imperial College, London, U.K.

KEYNOTE ADDRESS

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LASER TECHNOLOGIES IN INDUSTRY
6-7-8 June 1988 PORTO PORTUGAL

Laser applications in modern industries

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ABSTRACT

A short historical review, as well as trends in the laser industry will be be reviewed. The major portion of the paper will summarize specific applications of laser technologies in semiconductor manufacturing, material working, laser radar, electric power cable manufacturing, power recovery in gasoline refineries and nondestructive testing.

1. INTRODUCTION

The field of electronics was created by the invention of the vacuum tube at approximately the turn of this century. The heart of electronic technology is the device that amplifies the flow of an electron stream (electrical current) either in a vacuum (i.e., the vacuum tube) or in a solid (i.e., the transistor where the flow of positively charged "hole" can also be controlled with appropriate configurations). The word "electronic" was created by adding "ic" at the end of the word "electron." Since laser devices amplify the flow of a photon stream (light), the laser can be considered to be the heart of the technology that has been called quantum electronics in the past. More recently, some technologists have carried this analogy one step further and encompassed the field of quantum electronics; including, lasers, opto-electronics, electro-optics, acousto-optics, fiber-optics integrated optics, nonlinear optics, etc., into the new term "photonics" by adding "ic" at the end of the word "photon."

One should not jump to the conclusion that electronics and photonics technologies compete against each other. Instead of competing, these two fields complement one another. Photonics is heavily dependent on electronics technology. Photonics is useful for those tasks that cannot be performed by electronics technology. By performing such tasks, photonics has already created new segments of existing industries, and by doing so, photonics is further expanding the base of electronic technology.

One cannot help but notice the analogy between the role played by gas lasers and optically pumped solid state lasers in developing the industrial base of lightwave technology during the beginning of the field of quantum electronics and the role played by vacuum tubes in developing the industrial base of the radio/microwave/ millimeter wave portion of the electromagnetic spectrum during the early days of electronics. In addition, one cannot help but notice the analogy between the role the semiconductor diode laser and the transistor have played and are continuing to play in developing the industrial base of their respective spectral regions.

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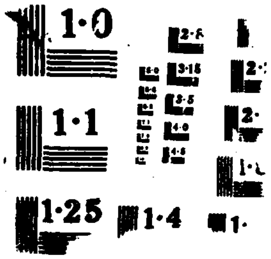
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Important factors for resource allocation in applied research and development

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ABSTRACT

Competitiveness of modern societies requires optimum allocation of capital, qualified workforce and organizational infrastructure with the connecting link determined by information technology. Human resources of the scientific and technical community can compensate limited resources of other types supported by enhanced information promotion mechanisms in applied research and development. Descriptive features of the problem dimensions are given as a frame of reference, and important factors are reviewed for possible consideration in the fields of technology policy, resource allocation methods and management practices.

1. INTRODUCTION

Many societies are at present subject to a transition period caused by technological innovations and transnational technology transfer. The resulting future society may be outlined in scenarios of desirable technical, cultural and social systems. The achievement of the future expectations requires the reasonable allocation of capital, qualified workforce and organizational infrastructure.

Control and management of R&D processes are an indispensable prerequisite for the successful approach of the future. They are interlinked with questions of technology policy, resource allocation methods and technology management practices. Prevalent views have considerably neglected the most precious resource in R&D processes - the human being. The potential of qualified scientists, engineers and technicians is essential to master the challenges of the future.

Information and information technology are another important, stimulating and connecting resource in the phases research, development and diffusion of technology. Availability, processing and dissemination of information is a historical agent and a contemporary basis for technological and structural change. Today, information and its supporting infrastructure is the necessary prerequisite for innovation and technology transfer.

However, societies and individuals are differently prepared and suitable to accomplish maximum efficiency in technological progress and competitivity. This fact raises questions about human factors and behavioural patterns involved at different organizational levels of control and management of technology. It seems necessary to investigate the important factors which may influence the human behaviour at the scientist-place of work or to reveal man factors which may improve the achievement of high-level research and development objectives.

The views presented here are intended as a survey or review of factors and aspects which can play an important role when taken into consideration for resource allocation schemes in applied R&D. The features have been collected within varying context, and were transferred to conditions of technological and structural change in socio-technical systems. They should be helpful to provide a frame of reference or glossary of terms for further considerations.

2. TRANSITION ASPECTS

Different scenarios may be imagined for the further development of the contemporary societies. A fan of pathways will be spread out by the starting and boundary conditions. The navigation into the future is hindered by the variety of development possibilities and the limitation of available resources. Speed and direction of the true course will be determined through the appropriate allocation of resources. Deviations from the foreseen courses can be possibly avoided by predictive measures about the expected technological and structural changes.

Technological forecasting and assessment can contribute to envisage future situations. The implications of new technologies will have effects on economy and employment. New technologies are welcomed for reasons of economic growth and prosperity but may interfere with social, cultural and environmental compatibility. The CEC (Commission of the European Communities) had therefore initiated and funded many research activities within its

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INTEGRATION AND CONVERGENCE OF TECHNOLOGIES - A CHALLENGE FOR EUROPE

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ABSTRACT

In this paper a long term fusion of microelectronics, photonics and functional materials in basic product components is assumed. Application fields are the opto-electronics in devices of communication technologies, sensors, laser informatics and measurement and control technologies in general. This movement is called the fusion of basic technological families or optomatronics in a study for the FAST Programme of the Commission of the European Communities. The development towards optomatronics is seen in the long term as important as the movement towards mechatronics (the integration of electronics in mechanical products) which occurred since the mid 70's and was put into effect by industrial policies in Japan. It has caused turbulent impacts in mechanical engineering, machine tools, the clock and watch industry and precision engineering in Europe. The same turbulent impacts might arise for industries affected by optomatronic development. This should be counteracted by the appropriate industrial policies.

1. INTRODUCTION

In addition to other areas, the research programme for Forecasting and Assessment in Science and Technology - FAST - of the Commission of the European Communities, DG XII, has studied the industrial prospects for the "technologies of light" - microelectronics, product applications and new materials. In particular, the European research network for technologies of light has concentrated its efforts on:

- lasers and their accessories
- fibre optics and accessories
- systems for the capture, processing classification and exploitation of image data.

The outcome of this scanning, assessment and forecasting activity shows the importance of this technological family for industrial purposes[1] which has been over-shadowed by microelectronics. In resumption of these facts and consideration of other studies conducted by the research programme aimed at RTD policy consultation, a dossier[2] has been established which points out the strategic relevance of the fusion of basic technological families and its industrial impacts.

A central message of that dossier is that in addition to the process of introduction of microelectronics into electromechanical products, a similar process will occur with technological families which have already or will strongly enter into traditional manufactured products. They will substitute other technologies, create new products or improve the functions of traditional products. These new technological families are light (optical technologies or photonics) and functional materials. As already stated, the fusion of basic technologies (electronics, photonics and functional materials) in components and the integration of those components into products is called the move towards optomatronic related industries.

It is assumed that technological fused components will be just a part of a bigger product. Similar to the chip is the heart of microelectronics as a component for a calculator, machine tools, CNC control, etc. Optomatronic components will be integrated in products like measurement instruments, communication facilities or household equipment. They will particularly go into products or areas where today already electronics have had a breakthrough because fused components are associated with information, communication and control functions.

The move towards the fusion of basic technologies and its integration with traditiona products is not directed towards a single industry. Like microelectronics, it influences a broad range of industries and can be called a generic or basic technology.

2. THE INTEGRATION OF TECHNOLOGIES

The integration and combination of technologies is a well-known historical phenomenum. But it has now accelerated its pace, and will do so further. The traditional automation technologies in factories, as well as in households (washing machines, air

Optical and Laser Technologies: The Next 25 Years

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ABSTRACT

This review presents some major projections respecting the next 25 years of optical, optoelectronic, and laser technologies. The projections given are extrapolations of present knowledge, with emphasis on industrial and manufacturing applications of these technologies.

1. OPTICAL/OPTOELECTRONIC/LASER TECHNOLOGIES

The past 25 - 30 years of optical and laser technologies have seen optics transformed from a last-century, "dull" subject into an exciting, leading-edge technology, optoelectronics arise from the marriage of optics and the newer technologies of electronics and microelectronics, and lasers discovered and developed into useful tools for science, engineering, medicine, commerce, industry, and consumer markets. The next 25 years will see these technologies reach maturity and demonstrate their full capabilities. At least one expert has stated that within 20 years, virtually all signals will be transmitted optically. It is natural and advantageous that optical signals be processed and stored optically as well, and optical signal processing and storage technologies have already entered several mass-market applications. Lasers are finally becoming commonplace in industrial operations, as they have been for some time in many areas of science, medicine, and commercial activity. A review of the current status of optical, optoelectronic, and laser technologies, and of their present directions d progress, permits the formulation of some major conjectures respecting their next 25 years, with emphasis placed on the industrial and manufacturing applications of lasers, optics, and optoelectronics.

These conjectures are as follows, listed in arbitrary order:

- Few truly new types of lasers will appear; existing types will continue to evolve, with trends toward simpler, more compact, more reliable, lower-cost laser types and designs, such as light-emitting diode and diode laser pumped solid-state lasers, having performances equal to, or better than, those presently available.
- Certain types of lasers which are now in their infancy, notably phased-array semiconductor diode lasers, tunable fiberoptic lasers, and free-electron lasers will be developed to become useful and commonplace tools.
- X-ray and gamma-ray lasers, lasers based on interactions of matter at high energies and densities and controlled nuclear and thermonuclear reactions, lasers evolving from ongoing work on advanced weap-

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Electrooptical Technologies

Finalized Program of Italian National Research Council (CNR)

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The preliminary study of this program started in 1983 and the authorization to CNR for preparing a feasibility study was given by the Italian Minister for the Scientific and Technological Research on April 4, 1986.

Experts from CNR, Italian University and Industries operating in the field of electrooptics partecipated to these studies. The final approval for this program, as well as for other nine programs operating in different fields, was given from the Italian government on May 28, 1987. From that date CNR started the operations for appointing the Steering Committee (Director and subproject coordinators) and Project Technical Committees while the regulations, already existing for managing these programs, were revised according to some Government indications. In order to advertise at maximum the different programs and assure a large qualified partecipation, the announcement for partecipation was published in the main italian daily newspapers, establishing as deadline for proposal submission November 30, 1987. The proposals submitted for this program were about 150 which are now being examinated by the steering committee and experts (two for each proposal) appointed by the project committee, who will report to the Project Technical Committee for final decision. Subsequently an executive program will be defined to be submitted to CNR Presidence for approval.

This project follows another project on "Power lasers" expired at the end of 1982. Its specific and qualifying purpose is constituted by the development of prototypes of systems with relevant degree of innovation and of interest for a variety of applications. The choice and aim of the considered systems have been didacted by precise market previsions. The activity of the program is organized within four subprojects, two of which are aimed to the study, design and construction of prototypes of electrooptical systems, while the other two are concerned with the research and the development of the related necessary active and passive components.

The project is divided into the following four subprojects:

SP1 Systems for industrial processing and diagnostics

SP2 Systems for information, environments and defence

SP3 Electrooptical active components

SP4 Electrooptical passive components

A particular task in charge of the Direction of the Project is to provide a continuous updating also with meetings with international experts on these Systems for Applied

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Entrepreneurial aspects for industrial applications of laser technologies

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SLIDE 1/12

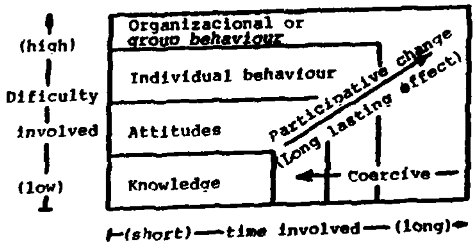
In order that industrial applications of laser technologies, or other, may be successful in the markets, it becomes mandatory that they meet usual accomplishment criteria in the entrepreneurial world.

Among the requisits for success we mention:

1. Development of conditions favourable to change
2. The practice of industrial projects discipline
3. The knowledge, acceptance and good use of the conditions, organization and rules that characterize financial markets
4. The respect of the strategy and top management basic concepts.

SLIDE 2/12

TIME SPAN AND LEVEL OF DIFFICULTY INVOLVED FOR VARIOUS LEVELS OF CHANGE



As a rule, change in an industrial environment implies:

- New technics for actual products
- New technologies for new products
- New methods or procedures
- New organization

(Hersey and Blanchard diagram in ILO-Geneva, Management Consulting)

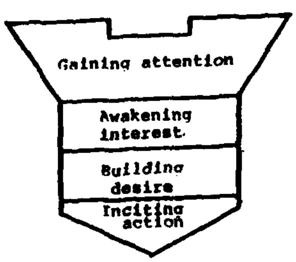
Planning and budgeting for training and development are required.

"We have plenty of management scientists, but what we need is management engineers". Prof. Lee (M.I.T.).

"The world needs simple models based on sophisticated assumptions". Mr. Sloan (G.M.)

SLIDE 3/12

IMPLEMENTING CHANGE - FOUR USEFUL STEPS



The most effective and immediate way for gaining attention seems to be to introduce a state of anxiety.

The interest may be arosed by calling attention to the benefits of change in the circumstance.

The desire may be reinforced by the analisys of alternative solutions.

Participating in the results of change incites to action.

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Eureka : High Power Solid State Laser European project

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Within the Eureka program, the High Power Solid State Laser project has come to the realization phase. It is devoted to the development of lasers for industrial applications with output powers above 1 kW.

A "definition phase" was held between May 1986 and June 1987, by four participating countries (France, Germany, Italy and United Kingdom), and permitted to specify economic objectives and industrial collaboration between European partners, and set technological directions. Now, a technological agreement between two industrial companies (HAAS LASER Germany and QUANTEL France) and two academic organisations (FLI Berlin and IEQ Florence) forms the central part of the project, and permits the coordination of technological developments in many other participating companies and laboratories.

The first year of phase I will lead to the realization of a more than 1 kW laser. It was determined as a limit for the use of rod technology. In parallel, works on slab lasers go on in order to achieve the 3 kW laser (5 years). For these power levels, efficiency becomes a critical parameter.

At the same time, in order to fully characterize material processing, a strong effort is pushed around what is called "applications". Numerous institutes are determining the parameters of laser - matter interaction at the kilowatt level. This interaction between laser manufacturers and applications specialists is one of the most interesting features of the program.

Other developments concern the many technologies associated with the laser, as there are pump lamps, crystals, coatings and cavities.

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Optoelectronique Laser-Realization et Success

C. Liegeois

(Manuscript Due)

Strategy on Laser Technologies Uses in a Research Laboratory

K. Geissler

(Manuscript Due)

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<u>**Atelier Laser - Une reussite**</u>

G. Mattiew

(Manuscript Due)

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LASER TECHNOLOGIES IN INDUSTRY

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OPTICAL METROLOGY

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OVERVIEW OF OPTICAL METHODS IN METROLOGY

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ABSTRACT

The aim of this paper is not to give a long and tedious description of all the optical methods used in metrology, but to draw some general specific propertiers and ideas illustrated by representative applications.

Impact of non-linear optics, optical waveguides and holographic optical elements are selected fields for this review.

1.- INTRODUCTION

Metrology consists to CONTROL, to MEASURE or to DETECT QUANTITATIVELY of (and) QUALITATIVELY, in a WIDE-RANGING FIELDS, some TYPICAL PROPERTIES of a SCENIC GEOMETRY like

- distances - forms - displacements - rotations - accelerations - velocities
- strains - buckling - state of surface - mapping contours - flaw detection
- crack detection - level - densitometry - volume capacities - proximity detection -
- torque...

or some EXTERNAL FIELD like

- temperature - pression - acoustic pression - gas detection - density -
- concentrations - spectral absorption - humidity - moisture - magnetic field -
- electric current...

in view of BETTER UNDERSTANDING OF PHYSICAL EXPERIENCES, IMPROVEMENT of PERFORMANCE, CONTROL OF QUALITY, SAFETY or ECONOMICAL CRITERIA,.....

The optical techniques are powerful in metrology because of their great precision, flexibility, non interaction (or small interaction) with the object to analyze, and the *very wide-ranged possibilities* based on the following light properties.

GEOMETRICAL POSITIONING : ALIGNEMENT (f.i. pipe-lines), TRACKING (f.i. for repetitive mechanisms), TELEMETRY (classical and laser), POINTING, PHOTOGRAMETRY, DEFLECTION, SCANNERS,...

INTENSITY: DETECTION (all photodetectors), ABSORPTIONS, IMAGING (f.i. image difference), INTENSITY MODULATORS, INTENSITY SENSORS, INSPECTION, CONTROL, DENSITOMETRY, SHORT PULSES PRODUCTION....

PHASE EFFECTS: INTERFEROMETERS (vibrations, deformations, index variations, coherent sensors, strains, non-destructive testing, mapping contours, high precision displacements set-ups...) FOURIER ANALYSIS ((de) convolutions, correlations, filtering,...) SPECKLE METHODS, PHASE CONJUGATION EFFECTS...

POLARIZATION EFFECTS: PHOTOELASTICITY, STOKES PARAMETERS (f.i. study of roughness), SENSORS, MODULATORS (FARADAY, POCKELS CELLS, ...)....

SPECTRAL ANALYSIS: ALL SPECTROSCOPICAL SYSTEMS, LIDARS (f.i. air pollution), CONCENTRATIONS MEASUREMENTS,...

INCOHERENT SPATIAL FREQUENCY BEATING EFFECTS : all the MOIRE methods (rotations, strains, displacements, contours,...)

FREQUENCY MODULATION: all the HETERODYNE methods, DOPPLER effects.

4b

LASER TECHNOLOGIES IN INDUSTRY

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LASER

BEAM

METROLOGY

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Non Contact Measuring Machine

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P. Sebastião

B. Henriques

(Manuscript Due)

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AUTOMATIC MACHINE FOR SPIN TESTING

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ABSTRACT

One of the bottle necks of the defence industry is the fuze testing. This task must be performed twice for each fuze. It is a 100% test, since all the fuzes must pass two tests.

The arming test is performed at an high rotation speed, and it is necessary to guarantee that a minimum diameter is open. The non arming speed must guarantee that a too small aperture has not happened.

The usual way to test the fuzes is the visual inspection by experienced operators. This method presents several problems and is always possible to have some faults.

To solve this problem, it was developed a special purpose machine to perform this task in a completely automated way. The results of this development are presented in this paper. The optical system which incorporates a laser and the interface with the mechanics of the machine are analysed.

The prototype is installed at INDEP and being used for the automatic testing of the fuzes.

A description of the optical system and its characteristics are presented in detail.

INTRODUCTION

In order to solve one of the bottlenecks of the national defence industry a machine has been developed and build to automatically perform the arming and non-arming tests of fuzes at the production line.

Each fuze must be tested twice: at the non-arming test, performed at a low speed of rotation, it is necessary to guarantee that the shutter doesn't open to a very small value; at the arming test it is necessary to guarantee that a predefined value has been reached by the shutter.

THE MACHINE

The machine incorporates three main parts: the structure, the spin rotation system, the pneumatic system and the optoelectronic system.

Fuze rotation is achieved by means of an electric motor that transmits movement to two spindles one at 1100 rpm and another 1300 rpm.

The pneumatic system is responsible for the semi automatic feeding of the fuzes, its rejection and also for the mechanical connection between the fuzes and the spin test points.

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NON CONTACT MEASURING MACHINE

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ABSTRACT

One of the problems of the production of cables is the measurement of the thickness plastic cover at the production line.

If for some reason the thickness of the plastic is smaller than the minimum necessary several meters of cable may be lost. If the problem exists in the middle of a long cable and the default is not detected in time, the loss will be significant.

solve this problem it is possible to use automatic measuring machines which may detect a default as soon as it happens. It is also possible to interact with the production line in order to avoid any losses.

In this paper it is presented a non contact measuring machine, developed for this purpose.

The machine uses a laser which is scanned through a field of 80 mm. The interruption of the beam gives information about the external dimension of the object.

The technical study of the resolution, sensitivity and precision are presented on the paper. Also the hardware solution and the software are presented.

The machine has an interface which allows communication with a PC. The PC may receive the information from several measuring units and to interact with machines installed at the production line.

The prototype is finished and is going to be tested in the industry.

Key words: Non contact, measurement, laser, scanning.

INTRODUCTION

The measurement is an important task when high quality is wanted.

The prototype presented here was develloped for the automatic continuous measurement of the external diameter of cables at the production line.

The prototype presents a very simple configuration to guarantee a low cost for the machine. The simplicity of the optical system and of the hardware is of great importance to this project.

Although very simple the machine is prepared to be connected to a personal computer which may receive information from several machines.

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LASER SCANNER FOR AUTOMATIC STORAGE

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ABSTRACT

The automated magazines are beeing used at industry more and more. One of the problems related with the automation of a Store House is the identification of the products envolved.

..ady used for stock management, the Bar Codes allows an easy way to identify one .roduct. Applied to automated magazines, the bar codes allows a great variety of items in a small code.

In order to be used by the national producers of automated magazines, a devoted laser scanner has been develloped.

The Prototype uses an He-Ne laser whose beam scans a field angle of 75 degrees at 16 Hz. The scene reflectivity is transduced by a photodiode into an electrical signal, which is then binarized. This digital signal is the input of the decodifying program.

The machine is able to see barcodes and to decode the information.

A parallel interface allows the comunication with the central unit, which is responsible for the management of automated magazine.

INTRODUCTION

.ne of the problems linked with the automation of warehouses is the identification of the products involved.

Already used for store management, the barcodes allows a great variety of items in a small code and an easy way to identify one product.

In order to be used by the national automated storehouses, a devoted Laser Scanner has been develloped. Using a very small He-Ne laser (LBR 7647 - Siemens) 0,5 mw and the simplest polygonal mirrow - two faces, this prototype is able to read any type of barcode once the software to do that has been developed.

THE METHOD

Due to the great possibilities of processing and stock management offered, barcodes are now widely used.

A barcode is a self contained message with information encoded in the physical widths of bars and spaces in a printed pattern.

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Interferometric alignment by a Circular Zone Plate

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ABSTRACT

A simple method for optical alignment and positioning between two planes by means of a Circular Zone Plate (CZP), is proposed.The first plane is determinated by the zone plate and the other one is related to position of a reflecting surface situated in the forward space of the zone plate.Two points sources are generated by the same zone plate,when it is illuminated by a plane wave, and by several diffracted orders reflected by the reflecting surface.. Interference pattern produced by two spherical waves depend on the relative position of the generating sources. Tilting or axial misalignment between the planes determine the relative position of the two point sources and it yield fringe pattern variation.

1. INTRODUCTION

Zone plates have been classicaly described as beam-splitter to set-up a common-path interferometer in order to test optical surfaces[1,2,3]. Recentely there has been a revival of interest in the zone plates, as important elements in optical metrology[4,5,6,7,8]. In this paper a simple and accurate method for optical alignment and positioning between two plane surfaces by means of a transmssion zone plane,is proposed.

2. ZONE PLATE INTERFEROMETER

It is well known that the interference pattern produced by two spherical waves, at certain observation plane, is strictly depending on the relative position of the generating sources. We propose to generate two point sources, one of them related to the reference plane, defined by the zone plate; and the other with the reflecting plane surface (for instance a mirror) that must be alignment respect to the first one. So,the fringe pattern produced by superimposition of the waves produced by these sources, allow us to make quantitative measures of the axial and lateral displacements between them and consequently between the plane surfaces. Now we propose a method for alignment a common-path interferometer by using the diffracted orders produced in the reconstruction of a Circular Zone Plate (CZP) processed under linear conditions. In order to make its alignment easy, it is convenient to proceed as follows: Assume that a monochromatic plane wave is normally incident on the CZP placed in front of a mirror,as shown in Fig.1.

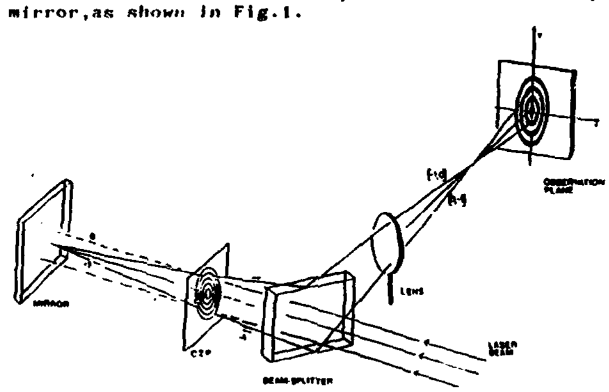

Fig.1 Schematic arrangement

We considerer only two kinds of wavefronts transmitted by CZP derived of the incident plane wavefront. The first kind consists of the direcly transmitted wavefront (non-diffracted order) and the second consist of the first positive diffracted order (+1) at the CZP. These wavefronts are reflected by the mirror and transmitted again by the CZP. The light emerging from the common-path interferometer consists of several diffraction orders; two of them are (+1,0) and (0,-1) orders that may be regarded as provenient of two point sources respectively. When the interferometer is adjusted, these sources are coincident, and consequently, they produce an uniform illuminated field at an observation plane;but if the interferometer is misadjusted,we can observe a weak fringe pattern at the observation plane

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Use of Talbot interferometry to measure the focal distance of refractive/reflective imaging systems

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ABSTRACT

for the measurement of focal distances of refractive and reflective imaging s on Talbot interferometry, is presented. The experimental conditions and limit s application are studied in order to maximize the measurements accuracy.

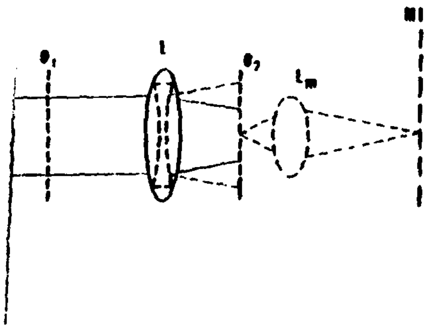
I. INTRODUCTION

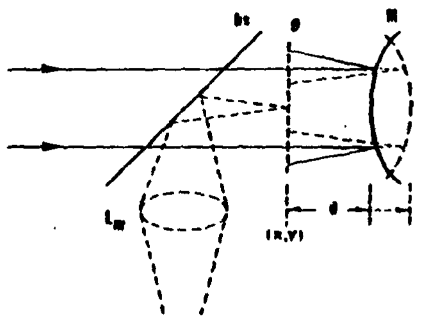
imaging properties of periodic transparencies when illuminated by a plane wav iown for a long time[1]. Talbot interferometry, resulting from the coherent inte modified self-image and the object or its replica, has been used for several s[2-5]. The properties of Talbot interferometry with self-images modified by an :em have been recently studied in ref.6. There, the spatial frequencies of the :erence pattern have been related with both the object spatial frequency and t up characteristic lengths. These relationships led to the establishment of a :o measure the focal length and to find the location of characteristic points of any imaging system.

aper, we discuss the experimental conditions and data manipulation which lead controlled and accurate measurement for focal length of positive and negative rors.

II. PRINCIPLES OF THE METHOD

.,a.b) show the geometries for testing refractive and reflective imaging syste :wo entical 1-D periodic transparencies, with spatial frequency ω_1, at dista l_2 from the lens are used. The moire interference pattern is observed at plane fig.1b), only one transparency is used; the interference pattern is observed at a distance $d=d_1=d_2$, from the mirror. For an accurate measurement of the :n period, planes (x_2,y_2) and (x,y) are magnified by a lens L_m (drawn with s in the figures).





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The applications of laser beams to absolute photodetector calibration

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MP8

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ABSTRACT

The importance of laser radiation sources in photodetector calibration processes is considered and shown. As an example of that, a recently made work comparing the spectral radiant flux measurement uncertainty of several absolute radiometers is described.

1.- INTRODUCTION

Detector response to optical radiation depends on light beam properties, such as power spectral distribution, power spatial distribution, polarization, beam divergence and modulation rate and form. It also depends on detector characteristics, such as light-detector interaction type, material in which detector is based on, detector internal structure and even detector size. Environmental characteristics, such as temperature, back ground radiation and mechanical or electromagnetical noise sources, are important too in measuring detector response. There is one more aspect to be considered: the way in which response is measured. This is important, because many times the instrumentation used may disturbs and changes detector response.

To calibrate a photodetector in absolute values means to know how much response the detector will give with respect to a certain amount of incident radiant power. To do it accurately it is necessary to keep well under control all parameters which affect the measurement, because the better they are known, the lower uncertainty will be obtained. Because of that, laser radiation sources are very useful tools in photodetector calibration procedures.

Laser beams have been used in the Laboratory of Radiometry at the Instituto de Optica from several years. Recently they have been used as radiation sources to compare the uncertainty of several commercially available absolute radiometers in measuring spectral radiant flux. This work will be described as an example of the importance and utility of laser for detector calibration.

2.- IMPORTANCE OF USING LASER BEAMS IN ABSOLUTE PHOTODETECTOR CALIBRATION

Laser sources present some advantages against other radiation sources. They emit a thin beam in a well defined direction having a small degree of divergence and with high power density. Therefore many auxiliary optical components are not needed. They also emit in a very narrow and fixed spectral interval, which for most radiometric purposes may be considered to be a single wavelength. Therefore it is possible to eliminate all wavelength depending errors, which can be of great importance in calibrating selective detectors. Besides many laser sources emit polarized radiation and even if they do not do so, it is easy to polarize their output beam. Some of these statements are not true for laser diodes, that require special treatment.

In the other hand, it is necessary to be careful when using these sources to calibrate photodetector, because some of the characteristics previously cited as advantageous might be disadvantageous, regarding to detector response saturation problems, for instance.

An example of the importance of laser beams in absolute photodetector calibration is the self-calibration method[1]. It is claimed that the uncertainty of this method (applicable to types of silicon photodiodes) is less than 0.1%, which would be very difficult to obtain without the use of a laser beam.

3.- INTERCOMPARISON OF ABSOLUTE RADIOMETERS AT SEVERAL VISIBLE LASER WAVELENGTHS

Absolute radiometers are widely used not only to realize radiometric scales, but to measure radiant power of many other applications where absolute values are needed. There are different types of absolute radiometers based on different materials and measurement principles. All of them are supposed to be accurate in 1% or better, but in measuring radiant power some other uncertainty sources, such as sensitive surface inhomogeneities, may increase the ultimate error of the measurement.

Since three different absolute radiometers are available in the Laboratory of Radiometry at the Institute of Optics, it would be interesting to measure the optical power of a light

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OPEN FIELD PHASE MEASUREMENT TELEMETER FOR ORBITAL RENDEZ-VOUS

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ABSTRACT

For about four years, collaborating with its industrial and scientific partners, CNES has studied the different types of optical sensors that could help to fulfil an impactless rendez-vous and docking mission between two spatial vehicles moving on a low orbit around the Earth. As a part of that activities, a study realized by Sercel and CNES resulted in the definition of a phase measurement rangefinder able to measure distances from 2 to 500 meters with an accuracy varying from 20 millimeters to 40 millimeters at a rate of 1 Hz. The range and the field of view (±5°) of that instrument together with specific constraints due to spatial environment lead to choose high power (100 mW) current modulated continuous wave laser diode as lightning source for this application. As a matter of fact, the target satellite must keep passive during the mission. Furthermore, the sensor must work in open field to avoid the use of mechanical scanning systems and must be able to deliver a correct information even if the sun is in its field of view so that the rendez-vous scenario is not constrainted. Last, semi-conductor technologies have been preferred because their spatialisation seems to be simpler. Yet, a speckle phenomenon due to the multimode optical fibre onto which the laser diode is connected appears in the field of view. That phenomenon, associated to the dynamic behaviour of the component (spectral drift versus current intensity) prevents the sensor from delivering an homogeneous answer in different points of the field. The phenomenon has been analysed and a solution implying an adapted modulation for the laser diode is proposed. The global sensor principle is described.

1. INTRODUCTION

Research on sensors to be used for in-orbit operations has now taken a new direction with the increasing development of the orbital infrastructure. Indeed, conventional stellar or planetary sensors no longer meet the requirements for the type of missions now planned. An impact-free rendezvous between a hunter and a passive target, for instance, can only be successfully completed if the docking vehicle is equipped with a range finding system able to evaluate the relative position and attitude of the two vehicles. Investigation in this field over the past few years has lead to a clear definition of range finding requirements[4].

Phase measurement telemetry was rapidly adopted as one of the concepts likely to meet a certain number of these requirements, namely the ability to measure the distance and relative velocity between hunter and target. The specifications pertaining to an instrument of this type are summed up in the table below.

Range	2m - 20m	20m - 100m	100m - 500m
Field	± 5°	± 5°	± 5°
Range finding accuracy	0,01 x d	0,01 x d	0,01 x d
Velocity measurement accuracy	5 mms^{-1}	5 cms^{-1}	10 cms^{-1}
Rate	1 Hz	1 Hz	1 Hz

The most demanding specifications are those concerning long range velocity measurement and close-up range finding.

The main research effort is thus reduced to designing a telemeter with a measuring bias of less than 20 mm and a resolution of less than 35 mm at 500 m.

However, a number of additional constraints are imposed by the fact that the system is to be exclusively used in space missions. The levels of reliability required for space flight (and particularly for manned space flight) are such that it would seem safer not to equip

SITPUL - A simulating system for firing instruction using laser.

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ABSTRACT

SITPUL System allows the individual firing and tactical instruction of small units, under economical, safe and realistic conditions.

The basic configuration of the SITPUL system is an Emitter (Fig.1) that uses a codified diode laser beam to simulate the shooting of a Weapon and a Receiver (Fig.2) that decodifies the information when a laser is detected.

Figure 1. Emitter

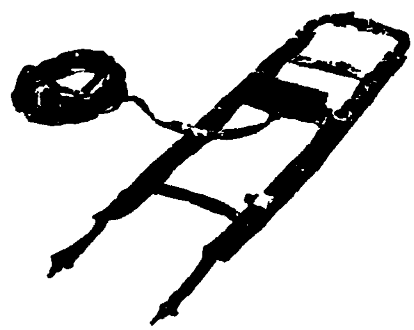

Figure 2. Receiver

1. INTRODUCTION

The simulation equipment for the tactical training of army units requires the ability to have parallel multi element comunication between a large number of men.

Laser systems have been known to have the required capacity. The system presented here, SITPUL, uses the laser to send words like "Kill", "Near Miss" "Recoverd" but also words regarding the identification of the shooter.

This new system does not allow for suicides. It does not fire the laser by shock waves thus preventing its functioning induced by other weapons in the exercise. It is software compatible with existing systems and it allows the reading of individual scores in the field.

2. EMITTER

The emitter has a configuration that can be represented by the block diagram shown in the Fig.3 a).

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Holographic

Interferometry

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Thermal rectifying walls: an interferometric study

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ABSTRACT

Energy storage is still an expensive operation in the sense that apart from the store itself, it also includes components for collection, transfer and control of energy flows. An interesting and important improvement would be achieved if the boundary of the store allowed heat transfer between the energy source and the storing material whenever the temperature gradient were favourable and inhibited the heat losses whenever such a gradient were reversed; in other words, the walls of the store would behave as thermal rectifiers.

In this work one presents the rectifying effect of a vertical parallelogramic cavity and its application to thermal rectifying walls which could be used in thermal stores. The operation of such walls depends on the enhancement or inhibition of natural convection heat transfer. Using a Mach-Zehnder interferometer front to back ratios of between two and three have been measured.

1. INTRODUCTION

The rectifying effect of an air-filled vertical parallelogramic cavity has been described elsewhere.[1] The operational principle of such a rectifier is based on the enhancement and inhibition of convective phenomena. A fluid-filled space is enclosed between two plane parallel walls ON and PM distance D apart and by two other parallel surfaces OP and NM inclined at an angle d to these walls and separated by a distance H along the vertical direction. The fluid is subject to a temperature gradient normal to the first pair of walls, the other two being more or less insulated. When wall PM is heated convection currents will be set up and heat will be transfered to the cold wall ON at rates determined by the properties of the fluid, the temperature difference and the dimensions of the cavity. On the other hand if the temperature gradient is reversed, then provided that the point P is lower than point N, the hot fluid, seeking always the highest point, will necessarily tend to remain in contact with the hot wall ON; the remainder of the cell will contain a stable cooler fluid. Under these circunstances natural convection will be inhibited and heat will be transfered "only" by fluid conduction. One can then say that the parallelogramic cavity acts as a thermal rectifier, transfering heat preferentially in the uphill direction. Rectification ratios - quotient between the heat flux trasmitted in the preferential forward direction and that transmitted in the reverse direction - of between 4 and 8 were measured for a cavity of aspect ratio A=H/D=1, temperature differences varying from 10 to 100 C and angle d between 25° and 45°.

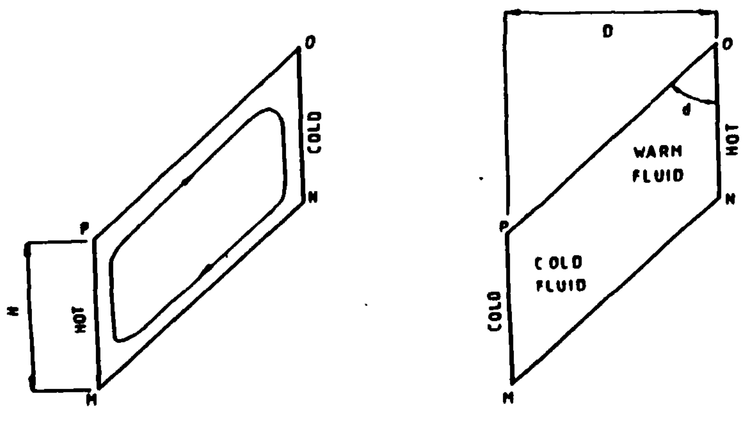

Figure 1. Thermal rectifier

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Natural convection in a one-sided heated vertical channel

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ABSTRACT

An experimental analysis of natural convection heat transfer in an open-ended vertical channel has been performed, with either water or air in the channel and in the ambient which surrounds the channel. Heating conditions were such that, one of the principal walls-the heated wall-was maintained at a constant uniform temperature (elevated with respect to ambient), while the other wall of the channel was unheated. Temperature distribution and governing heat transfer mechanisms in and out of the channel were observed by holographic interferometry and dimensionless heat transfer correlations were obtained.

1. INTRODUCTION

Natural, forced or mixed convection in vertical parallel-plate channels has received a fair amount of attention in the heat transfer literature, due to its importance in electronic cooling applications. Natural convection heat transfer from a single vertical wall has been investigated by many researchers and governing heat transfer correlations were obtained by both theoretical[1] and experimental[2,3] methods. There also exist various studies on natural convection between vertical parallel-plates. The thermal boundary conditions considered in most of these studies are symmetric and *asymmetric heating where both of the* plates are heated[4,5,6,7,8,9] ; and one-sided heating where one of the plates is heated and the other is unheated and adiabatic[6,10,11,12] . There couldn't be found a study concerning the heating condition in which one of the plates is heated to a constant uniform temperature and the other is unheated and conducting.

2. EXPERIMENTS

The heated wall was a 10 mm thick 0.10x0.20 m or a 20 mm thick 0.245x0.500 m aluminium plate equipped with an internal electrical resistance which could be supplied with direct *current through a DC converter*. The voltage applied and the current were measured by a multimeter and an ammeter which had resolving powers of 0.01 V and 0.01 A, respectively. The ambient temperature was measured with a digital quartz thermometer of resolution 0.01°C. Two 1 mm thick 0.10x0.20 m or 0.245x0.500 m aluminium plates were used as unheated plates. All surfaces of plates had emissivities equal to 0.95. Temperature measurements were made by Chromel-Alumel thermocouples at 8 points in the heated plate and 5 points in each of the unheated plates. Experiments in water were performed with the plates situated in a water-filled open-topped glass tank of dimensions 0.40x0.25x0.30 m. The plates, electrical circuit and measuring devices are shown in Fig.1.

Temperature distribution and heat transfer mechanisms were visualized with a holographic interferometer, using the real-time technique at both finite and infinite fringe width. The holographic interferometer setup used in the experiments is shown in Fig.2.

2.1. Experimental procedure

At first, experiments were carried out for the single vertical isothermal wall case by using only the heated plate and results were compared with relevant previous works present in the literature. Having thus ensured the experimental apparatus, two unheated plates were placed parallel to the heated plate, each at one side of it and with equal spacing, to analyse the parallel-plate channel problem.

The plate height (L) was 0.10 or 0.20 m in water and 0.245 or 0.500 m in air. The interplate spacing (s) was varied from 2 to 10 mm in water and 2 to 75 mm in air.

The temperature difference between the heated plate and the ambient ($\Delta T=T_w-T_\infty$) was in the range of 0.15 to 6°C in water and 20 to 100°C in air.

In nondimensional terms, the Rayleigh number based on the plate height (Ra_L) was kept between 10^7 and 10^9, where transition from laminer to turbulent flow occurs. The aspect ratio (H) was varied from 10 to 67 in water and from 6.7 to 125 in air.

$$Ra_L = \frac{g\,\beta\,\Delta T\,L^3}{\nu\,\alpha}$$

$$H = \frac{L}{s}$$

g: gravitational acceleration
β: coefficient of thermal expansion
ν: kinematic viscosity
α: thermal diffusivity

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5a

Tomographic presentation of temperature profiles in a convective heat flow by high resolution holographic interferometry

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ABSTRACT

The aim of these investigations is the development of a new experimental setup, allowing multidirectional analysis of phase objects by high resolution holographic interferometry. With this setup it is possible to obtain interferograms of finite width covering a range of view of 155°. The first tests were performed on a stabilized convective heat flow, since its temperature distribution could be measured with an NTC-detector, providing reference data to check the quality of the tomographic reconstructions.

To obtain highest resolution of the interferometric data, the holographic interferograms were evaluated using the formalism of the fast Fourier transformation (FFT).

The distributions of the index of refraction were obtained by two commonly used tomographic reconstruction procedures: the convolution method and the algebraic reconstruction technique (ART) showing better results, especially if the projection data are not completely covering 180° of view.

1. INTRODUCTION

On the problem of diagnosing inhomogeneous transparent media (e.g. gas flows, plasma jets, switching sparks, welding arcs) many investigations have been carried out until now by using a formalism for data reduction based on the Abel inversion technique assuming rotational symmetry of the phase object. Unfortunately the experimental conditions frequently cannot be satisfactorily adjusted to obtain this symmetry type with the required accuracy. Only a small number of authors have tried to modify the inversion techniques for asymmetric phase objects by different extensions of the Abel inversion procedure. On the other hand the X-ray computer tomography in medicine gives a completely spatial resolution over 360° of strongly inhomogeneous matter by applying suited reconstruction techniques. Our investigation should be understood as an attempt to apply the mathematical formalism of computer tomography to experimentally obtained optical data, especially by multidirectional holographic interferometry.

2. EXPERIMENTAL

2.1 Optical setup

Holographic interferograms of inhomogeneous transparent media (phase objects), which are recorded according to fig. 1, do not provide a multidirectional view of the interferogram from different directions. It is obvious that an arrangement with a diffusing screen[1] (fig. 2) must be chosen as a basic requirement in order to observe phase inhomogeneities by interferometry in a multidirectional way. The inhomogeneous zone - now being penetrated by light scattered from every point of the screen - can be investigated by a single hologram from different directions within a certain angular range.

The optical arrangement is shown in fig. 3. To obtain the largest possible angle of view the double exposure interferograms were recorded as reflection type holograms, allowing the observation of a phase object within 155°. In a specially designed real time plate holder HX three holographic plates are facing three diffusing screens.

In order to evaluate the phase shift of the interferograms using a Fourier transfomation algorithm, a vertical reference fringe system had to be superposed. This was achieved by rotating one common mirror RM. With a sandwich hologram SH[2], that allows to compensate the reference fringes by tilting it, the stability of the phase object during the exposure can be checked.

After developement the holograms were repositioned and the interferograms could be

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Holographic evaluation of stiffener configuration on cover plate of water box of an industrial heat exchanger

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ABSTRACT

Holographic interferometry has been utilized for obtaining design information on the cover plate of water boxes of industrial condenser. Experiments for this purpose have been carried out on a properly simulated epoxy model of condenser cover plate, which affords ease of incorporating the various configuration of stiffeners. An extensive numerical data analysis of the interferograms for these configurations has resultted in the evolution of modified stiffener arrangement. The modified stiffener configuration has been tested holographically and found to result in considerable reduction in deformations.

INTRODUCTION

In spite of availability of a variety of computer packages for structural analysis, experimental methods continue to play an important role in the analysis and design of complex and critical structures/components. This is due to the fact that many a time it is not possible to define adequately the boundary conditions of the structure while using package programs and therefore a recourse to experimental methods becomes a necessity. Moreover, in some equipments like condensers, it is not unusual to experience large bending deformations of various parts whereas the analysis is carried out mostly as per small deformation theory. Experimental testing and analysis are generally used for validation of designs as also for ensuring the reliability of structures. In many cases experimental investigations are required to generate data for optimization of design.

In view of the large deformations experienced by cover plates, at times, it is the general practice in design to increase the section thickness and to provide additional stiffeners. Since this exercise leads to an increase in weight, it is necessary to optimize these aspects. Since the problem of rational provision of stiffeners ultimately relies on the whole field visualization and quantitative measurement of deformations, holographic interferometry[1,2] is selected to solve this problem since this technique is best suited for displacement and deformation studies[3]. This aspect in combination with the use of an epoxy model to simulate the condenser cover plate (where stiffeners configuration can be changed easily) makes the choice of holographic interperfometry most ideal for the solution of the problem.

This paper presents the details of an experemental study on the various stiffening configurations in cover plates of the water boxes of two pass flow type of an industrial condenser having a complicated geomeltry. The cover plate is clamped at the separator periphery (Fig.1) and loaded by transverse fluid preassure uniformly. It is highlighted that the effect of the behaviour of the gasket between the cover plate and water box shell on the deformations can be easily and realistically studied using holographic interferometry on a properly simulated model.

SIMULATION OF STRUCTURAL SIMILARITY

Since the experimental analysis is proposed to be carried out through investigations on a structural model of the condenser coverplate, the various aspects to be considered prior to the fabrication of the model include i) geometrical size of the model, ii) material to be used for the model, and iii) exactness of simulation of various loads and boundary conditions in the model.

While in most structural analysis, the simulation aspects do not pose difficulties, in the case of condenser, difficulties arise due to the presence of a gasket between cover plate and water box structure. The gasket takes up part of the structural deflections and rotation during the operation of condenser. Use of the same gasket material in the model as that of actual condenser distorts the modeling parameters considerably. Thus, it is necessary to carry out computations for structural simulitude in an iterative manner for different geometrical size ratios as well as with different model gasket materials until the requirements of similarity are properly met. The analysis for obtaining magnitudes of the various structural geometrical and strength parameters is given below.[3,4]

A new full-field Phase Shift Method for Holografic Interferogram

Y.Y. Hung

X. Zhang

F.S. Chan

J.T. Ke

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Fast Holographic Camera for Industrial and Scientific Applications

M. Delepierre

(Manuscript Due)

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<u>NDT Holographic Testing of Tubes and Joints</u>

F.M.V. Pires de Morais

O.D.D. Soares

(Manuscript Due)

TP

Application of H.I. to a fracture mechanics Problem

M.A.P. Vaz

A. Lage

J. Gomes

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THREE-DIMENSIONAL DISPLACEMENTS BY SANDWICH HOLOGRAPHIC INTERFEROMETRY

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Summary

In this paper, the mathematical expressions for the three-dimensional displacements of an object by holography are given. The authors derive the general equations for strain and stress using sandwich hologram interferometry. The method has been verified experimentally.

Introduction

Sandwich holographic interferometry has many advantages over other holographic techniques. Tilting the sandwich holographic holder, we can compensate for the rigid displacement, so that the fringes remaining on the object relate to the deformation. Sandwich holography can be formed by different combinations of a number of N pieces of holograms correspond to N(N-2)/2 pieces of double-exposure holograms. As the result of the small angle between the object beam and reference beam in sandwich holography, there is not a stringent requirement for special vibration isolation. It can be used easily for in-situ measurement of practical engineering problems.

Sandwich holographic interferometry was first proposed by Nils Abramson in 1974 1-5 .The first study refered to a cantilever beam loaded at the free end by a force. Then other studies on sandwich holography emerged. In this paper, the mathematical expressions for the three-dimensional displacements of the object are given. The authors derive the general equations for strain and stress on the object by using sandwich holographic interferometry which is intrinsically different from the usual holographic interferometry where stresses are derived from the second derivative of the displacement. The method was verified exprimentally.

Principle

Figure 1 shows the general arrangement of the sandwich holographic interferometer.

Information related to the object prior to deformation is recorded on two pieces of plates (F1,B1) on the sandwich holographic plate holder. Information on the object subsequent to deformation is recorded on two other plates (F2,B2). The second plate from the first exposure and the first plate from the second exposure are processed and superimposed on one another before being replaced on the plate holder

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Improvements in moiré-holographic gratings for structural analysis

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ABSTRACT

The authors present a simple method of gratings manufacturing on perspex models, used for structural analysis. The technique is briefly described and the quality and efficiency of grids are discussed. Two simple applications are illustrated.

1. INTRODUCTION

The moiré-holographic method has been largely used in experimental mechanics[1]. Briefly it can be said that this method combines the moiré method with interferometric techniques based on the wavefront reconstruction of light. A monochromatic plane wavefront crosses a transparent model on which a grid has been traced. On reaching the grid, the light is diffracted into different wavefronts, which contain information about the model. These wavefronts pass through a lens and form in the focal plane of the lens a diffraction spectrum of Fraunhofer.

At this point, two symmetrical orders are filtered and their plane wavefronts interfere on a holographic plate. After a double exposure (before and after model deformation) a fringe pattern, proportional to u and v plane displacements, appears. This method is very attractive because it gives information about plane displacements on the whole field of the examined structure. Despite being a laboratory technique, it is very easy to use and allows a wide choice of sensitivity levels. Moiré-holography can also be used in real time[2] to record dynamic phenomena. As for the other moiré techniques, the basic element for obtaining accurate measurements is the grid. Brightness, precision and sensitivity of fringe pattern depend on the grid. In transparent moiré-holography the grid is more important because the wavefront crosses the model and the graticule.

This paper deals with the manufacture of a simple phase grid suitable for moiré technique. The quality of various grids is discussed and two simple applications, representing circular discs uniformly loaded out of plane, are presented. The results are then compared with analytical and numerical data.

2. GRID MANUFACTURE AND ANALYSIS

The phase gratings used in the present investigation are well suited to moiré-holography because they do not alter the transparency of the model. The grid must be manufactured following the below steps:

1. a grid is photoengraved on a normal holographic plate (Agfa 10E75) by means of two laser beams;
2. the plate is bleached to obtain a phase grating (using a potassium ferricyanide solution;
3. some bond (Acrifix 92 by Rohm) is put on the model and the plate is pressed onto it. At this point care must be taken to ensure grid lines are in the right sensitivity direction;
4. the model and plate are then exposed to sunlight for about an hour;
5. lastly, the plate is debonded leaving on the model surface a replica of the grid.

The plate is very easily detached because the bond used is a viscous solution of partly polymerized acrylic resin which does not adhere to the gelatin of the plate. Some steps of this manufacturing procedure are similar to those used by Post[3] for moiré-interferometry. But the aluminium coating, which is fundamental for Post, is useless here and can even impair model transparency. Different grids have been made with pitch values from 0.025 to 0.0005 mm. This range permits the study of virtually all problems connected with structural analysis. The highest sensitivity is similar to that of holography and many drawbacks arise in experimental set-up. Grid replicas are satisfactory up to frequencies of 700 and 800 lines/mm. Above this value a special bleaching must be used to enhance the phase grid of the holographic plate. Figure 1 shows the brightness profiles of both models and plates with 60, 205 and 960 lines/mm grid. These profiles have been obtained by means of a computer set-up. Even from these qualitative schemes a good reproducibility can be observed.

Ratios between power intensity of model and plate diffraction orders are reported in Table 1. As can be noticed, the 0 order increases while the others decrease. No appreciable losses of power intensity occur for this kind of problem.

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Trends in Moiré Holography

A.V.S. Lage

O.D.D. Soares

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LASER TECHNOLOGIES IN INDUSTRY

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OPTICAL METROLOGY

Computer Aided

Holography

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Computerized Holographic Techniques for Quantitative Evaluation

C. Liegeois

(Manuscript Due)

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A comparison of the methods available for the evaluation of holographic images

A. Ettemeyer, H. Rottenkolber, J. Schörner

1. Introduction

The outstanding advantage of holographic interferometry as a contact-free measuring procedure is that it enables very wide-ranging statements to be made on the behaviour of a component. Measurements are taken simultaneously at several points on the surface of the object, and the result can be assessed visually. For a more precise quantitative analysis, or for automatic evaluation in serial testing, however, evaluation by computer is indispensable. The theoretical basis for this was laid in part several years ago, and suitable equipment in a variety of standard forms has in fact been available on the market for a number of years.

This contribution attemps to provide an overall view of the various principles by which holographic interferograms can nowadays be evaluated, together with the areas in which each can best be applied.

2. Structure of an image-processing system

In order to be able to process amages in a computer, an image-processing system, or at the very last parts of such a system, is required. A whole range of systems exist, which can be integrated into a normal personal computer. They differ principally in terms of their efficiency (speed, memory capacity) and ease of use. Two possible versions are shown in Fig. 1.

A video-camera converts the recorded image into analogue voltage signals corresponding to the brightness of the pixels. The standard resolution at present is approximately 600 pixels per line, with rather fewer lines per frame. However, there are also cameras already available with a resolution of 4096 x 4096 pixels. An analogue to digital converter transforms the video signal into a digital signal, normally with a depth of 8 bits (corresponding) to 256 gray levels). These digital gray values can, by means of programable look-up tables (LUT), have any other values required assigned to them before thes are stored in the image memory. With the aid of such look-up tables, the image can, for example, be inverted, the contrast can be expanded and so on. The normal size of the image memory is 512 x 512 pixels, each with a depth of 8 bits. More elaborate systems are equipped with larger image memories (e.g. 1024 x 1024 pixels, 16 bit).

The computer has access to the image memory via the hostbus. It can address individual pixels and carry out any operation required on them. To display the aimages on an RGB-monitor, the contents of the image memory are once again transformed (if so desired) by means of an output LUT and then fed to the monitor via a D/A converter. In an arrangement of this kind, the actual processing of the image, that is the computation of the relationship between various pixels etc.- is carried out in the computer. The computer accesses the image memory via the host-bus, transfers a pixel or a field into its working memory and then stores the pixel or pixels om completion of the computation in the image memory once again. This operational transfer of the pixels from the image memory to the working memory and back frequently accounts for the major part of the time reqired for the processing of the image.

The more elaborates image processing systems are therefore equipped with a so-called ALU (arithmetic logical unit). The contents of the image memory are transferred, once again via look-up tables, into the ALU, where they are subjected to one or more operations before being returned via an output LUT to the image memory. This entire process requires in each case less than 40 msec (depending on the image processor) for the total contents of the memory. Complicated operations are carried out by means of repeated runs through the ALU. The role of the host computer is reduces to regulation of the process. It no longer carries

APPLICATION OF COMPUTER-AIDED EVALUATION FOR HOLOGRAPHIC VIBRATION ANALYSIS AND OPTICAL CONTOURING

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1. General

Holographic interferometry is applied sucessfully in vibration analysis.

As the resulting characteristic fringe pattern, the interferograms, are so complicated and can only be evaluated by an expert eye, there is a clear desire for automated evaluation and a lucidly arranged exposition. Therefore, the problem in image processing in interferometry lies in automatically recognizing and evaluating lines, as well as in differentiating the lines from object contours, shadows, etc. This kind of image processing then also makes it possible to evaluate other, non-holographic line systems. The application is not only limited to the automatic evaluation of holographic interferograms, but also in the optical measuring of the form any kind of objects using contour lines projected onto them, in the evaluation of speckle and photoelasticitic diagrams and Moiré diagrams.

2. Principle

The process of evaluation is based on a phase-shift technique of Dändliker (1). It was developed with the financial support of the BMFT and in cooperation with M.A.N. Technology Ltd.

A minimum of 3 images with a defined phase-shift are fed into the computer with a video camera (fig. 1). The evaluation is hereby traced back to a measurement of three times the intensity which can be carried out simply and with great accuracy using optoelectronic sensors. The result is a graphic, perfectly sketched and highly accurate representation of the line formation in the form of tables, fake colour graphics and isometric plots.

Interferometric Techniques, Data Extraction and Quantitative Analysis

R. Pryputniewcz

(Manuscript Due)

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NDT of Composite Materials, State-of-He-Art

J. Ebbeni

(Manuscript Due)

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On-line Fringe Analysis by Real-Time Phase-Shift-Processing

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ABSTRACT

This paper presents the concept of a real-time-processor for on-line analysis of fringe patterns which allows the recording of phase shifted fringe patterns and the successive analysis of the image data by the phase shift algorithm in video real-time.
In addition, examples will demonstrate the use of the phase-shift-processor in holography, speckle technique, moiré- and 3D-measuring techniques.

2. INTRODUCTION

The significant progress that has been achieved in the last few years in the field of computer aided fringe analysis lead to an increased interest in the application of a special group of optical measurement techniques in industry. In particular for holographic interferometry, speckle-interferometry, moiré- and projected fringe techniques new areas for industrial application arise provided that fast and reliable automatic analysis systems exist.

In the following, the concept of a fast-frame-processor will be presented, which enables one to record and analyse fringe patterns in video-real-time. The analysis is based on the phase-shift-method which has already been used successfully in quantitative fringe pattern evaluation in the last few years.

3. THE PHASE SHIFT ALGORITHM

For equidistant phase shifts φ_i, $i = 1 \ldots n$, $n \geq 3$ the solution of the phase shift education

$$I_i(x,y) = a(x,y) \left[1 + m(x,y) * \cos\left(\varphi(x,y) + \varphi_i \right) \right] \qquad (1)$$

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DIGITAL PHASE STEPPING SPECKLE INTERFEROMETRY

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ABSTRACT

A digital speckle interferometric technique for deformation measurement using phase stepping and image processing is presented. The object displacements on a 256*256 grid are calculated by subtracting the phases of the speckle field before and after deformation. Accurate phase measurement is achieved by using reference beam phase stepping and digitizing five interferograms to calculate the phase in each detector point. Application of image processing techniques, for instance new phase-unwrapping algorithms, allow measurement of displacements as small as 1 nm and up to 10 000 nm. Results of measurements of out-of-plane deformation of a circular metal plate are shown.

1. INTRODUCTION

In contrast with electronic speckle pattern interferometry (ESPI), digital phase stepping speckle interferometric techniques do not produce fringe patterns from which the phase change can be extracted by finding the fringe extrema. Use of a reference beam phase stepping technique and digitizing the interferograms allow the calculation of the phase modulo 2π radians in each detector point [1]. Because of the random phase distribution in a speckle field, the calculated phase values are only meaningful if they are compared to the result of a phase measurement of the same object before deformation. Subtracting the two phase measurements gives a measure of the object deformation in the direction of the sensitivity vector for each object point.

Inherent to digital phase stepping speckle interferometry is loss of accuracy in points with low modulation (dark object speckles) and saturated points (bright speckles). Digital detection and marking of these points [2] enables the replacement of the measured phase value at those points by that of a non-marked neighbour. Another problem involves decorrelation of the speckle fields before and after deformation of the object. This phenomenon sets a theoretical upper limit to the difference in phase change (e.g. caused by object tilt) between two pixels (detector elements) that can be detected [3]. A convenient choice in practice is setting the speckle size equal to the pixel size, resulting in a theoretical upper limit of 2π radians / pixel. In our present experimental set-up the upper limit is 0.3π radians / pixel caused by other restrictions. The repeatibility of the measured phase at each pixel is set by environmental conditions, stability of the laser source, accuracy of the phase stepping and accuracy of the digitization of the interferograms. Presently the repeatibility is circa 0.02π radians.

2. OPTICAL SET-UP AND COMPUTER SYSTEM

The experimental set-up (Fig. 1) consists of a conventional speckle interferometer coupled to a microcomputer system for digitizing the interferograms, controlling a mirror position in the optical set-up and measuring various parameters. An Argon ion laser is used with an output power of approximately 1 W. A Hamamatsu video camera coupled to a Datacube framegrabber is used to digitize the interferograms to 256*256 images with 8 bit pixels. Phase stepping is achieved using a reference beam mirror mounted on a Burleigh piezo-electric translator controlled by the computer system. The object used for studying the characteristics of the set-up is a circular metal plate with a diameter of 0.1 m. The load establishing the object deformation is set by a computer controlled electromagnet and characterized by digitizing the current through the magnet coil. The use of an image processing software package enables a variety of filters, transformations and arithmetics to be executed on the digitized interferograms.

3. PHASE MEASURING ALGORITHM AND IMAGE PROCESSING

The intensity distribution of an interferogram generated by a phase stepping speckle interferometer equals

$$I_i(x,y) = I_b(x,y) + I_m(x,y)\cos[\,\phi_s(x,y) + \phi(x,y) + i\cdot\Delta\phi\,], \tag{1}$$

where I_b is the background intensity, I_m the modulation amplitude, ϕ_s the random speckle phase, ϕ the phase difference

MICROVISION DYNAMIQUE ASSISTEE PAR HOLOGRAPHIE ET ORDINATEUR APPLICATIONS A LA MECANIQUE

P. BURGER - M. DELEPIERE *
P. MEYRUIES - J. HAWRYSZKIW **

Résumé:

Nous présentons les méthodes et un système permettant de voir et de comprendre certaines des caractéristiques mécaniques de pièces en utilisant les possibilités conjointes de l'Holographie automatique à développement instantané, du traitement numérique d'image par un logiciel spécialement développé pour l'Holographie, et de la synthèse d'image. Cet ensemble commercialisé par la société MICRAUDEL permet un accroissement très important du potentiel "qualité" de ceux qui l'utilisent.

1 - Introduction

Parmi les méthodes de contrôle non-destructifs, celle d'interférométrie holographique est certainement la plus complète, la plus fine et adaptée à tous types de matériaux, aciers, plastiques, fibres composites, bois, caoutchouc, etc..., et à tous types de contraintes ou microdéplacements, statiques ou dynamiques.

L'information sur le phénomène analysé se présente sous la forme d'un réseau de franges macroscopiques claires et sombres réparti sur la pièce testée. L'interprétation de ces franges permet de localiser les défauts de surface et internes de la pièce, et de donner un schéma global de sa déformée . On peut atteindre des précisions de l'odre de 1/2 micron à 1/100è de micron.

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Modular Holography

for Use in Industry

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0. Abstract

A new system of holography is presented. This modular testing equipment fulfils the performance requirements for industrial measuring equipment. A holographic camera-head module with the approximate dimensions of a television camera is installed close to or actually on the object to be tested. For holography using a continous wave laser it is necessary only to secure the object to a base-plate mounted on vibration insulators. This is not necessary if pulse holography is used. Because of its small size, the measuring head can also be attached directly to the test object. This largely eliminates the effects of movements of the whole body of the objects. The technical realization of modular holography was made possible by the use of glass fibres. A rigid connection between the laser and the measuring apparatus is no longer necessary.

The necessary light for the recording of the hologram is provided by the laser-base module and fed to the measuring head via a glass fibre cable. The hologram recorded by the measuring head is transmitted directly by means of a television camera to the computer-analyzer module, where it is evaluated and presented in user-friendly form. An example from industry is taken to demonstrate the use of the modular holography system.

Contents

1. Introduction

Today, holographic interferometry is successfully employed in many branches of industry as a powerful measuring procedure. Nevertheless, it remains an extremely laborious, expensive and time-consuming process, and as a result, its use is limited mainly to large concerns. In an effort to reduce these obstacles, Rottenkolber Holo-System GmbH of Kirchheim, near Munich, has developed, with financial support from the German Federal Research and Technology Ministry, a system of holography which circumvents the problems.

2. The modular holography system

2.1. Limitations of "conventional" holographic procedures

Up to now, the following problems have stood in the way of the widespread use of holography:

1. The sensitivity of holography lasers to shock, dust, dirt etc. have allowed their use only under specific environmental conditions.

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Hologrametric Dynamic Techniques

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Industrial Applications of ESPI

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Some new techniques with Digital Speckle Pattern Interferometry (DSPI)

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ABSTRACT

Digital Speckle Pattern Interferometry (DSPI) is presented as a real-time technique for a number of applications such as measurement of small displacements, displacement derivatives, contouring, and non-destructive testing. The implementation of DSPI on a commercially available image processing system is described. A method of fringe sharpening in DSPI is also presented.

1. INTRODUCTION

Speckle interferometry is a useful tool for the measurement of small displacements, displacement derivatives, vibration analysis, shape measurements, non-destructive testing (NDT) etc[1-3]. It involves the use of a photographic plate to make a double exposure record of the object before and after the displacement/deformation. The information, which is a fringe pattern, is extracted by filtering the specklegram.

Speckle interferometry can also be performed with electronic detection. This was first demonstrated by Butters and Leendertz[4]. The video processing of the signal can be used to generate correlation fringes which are equivalent to those produced by photographic processing. This is termed as Electronic Speckle Pattern Interferometry (ESPI)[5]. In conventional ESPI, an image of the object illuminated with a laser beam, together with a reference beam, is stored on a video store (video tape recorder, disc or solid state store). The subsequent frames are then subtracted electronically from this stored reference frame and displayed on a TV monitor. If the object is now deformed, fringes can be seen on the monitor in real-time, which are contours of constant displacement. To enhance the fringe contrast, the difference signal is electronically processed in a non-linear fashion, by high pass filtering, full wave rectification and squaring of the video signal before it reaches the monitor. ESPI overcomes the two stage process of recording and filtering encountered in speckle interferometry. The major feature of ESPI is its ability to display the correlation fringes in real-time but it lacks in resolution due to the limited resolution of the detector. Hence the speckle size at the image plane has to be adjusted to within the resolution of the detector which necessitates the use of small apertures of the order of F/40 or F/32. Some of the recent developments in ESPI have been reviewed by Tyrer[6].

In Digital Speckle Pattern Interferometry (DSPI), the speckle pattern data are processed using digital image processing techniques and a host computer[7]. The analog video signal from the TV camera is digitized and stored digitally. As the data is in a digital form we have more flexibility in handling the data by interfacing a host computer. The processed data is sent to the monitor after conversion to analog signal. In DSPI, fringes can be observed even if the speckles are not resolved by the detector[7]. A recent work makes use of a Reticon 100 x 100 diode array instead of a TV camera[8]. Although ESPI is a real-time technique, the existing works on DSPI make use of double-exposure method. In this paper we demonstrate the use of DSPI as a real-time technique. Several new techniques developed with our DSPI system are described using both double-exposure and real-time processing.

2. SYSTEM DESCRIPTION

The DSPI is implemented on a system which consists of a commercially available 'Intellect 100' digital image processing system interfaced to a PDP-11/23 plus micro computer. The framestore is a 512 x 512 x 8 bit memory, which means that the picture is made up of 512 x 512 pixels and the intensity at each pixel is quantized to 256 grey levels. Figure 1 shows the schematic of the digital speckle pattern interferometer based on a speckled reference beam, along with the layout of the image processing system. A is the test object and B is a diffuse reference surface. They are illuminated by a 7 mW He-Ne laser (λ = 0.6328 μm) and imaged on to the face plate of a 'LINK' video camera, which is connected to the image processor.

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In-situ Investigations of Deformations of Natural Stones by Electronic Speckle Pattern Interferometry (ESPI)

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ABSTRACT

Due to environmental stresses like weathering and pollution the deterioration of historically valuable monuments increases. A compact and mobile ESPI system is configurated and described, which allows the investigation of deformations in stones and walls in situ. A first measurement directly at a wall is presented.

1. INTRODUCTION

As a result of environmental stresses like weathering and air pollution the deterioration of human cultural heritage such as buildings, churches and monuments of natural stones, mural paintings etc. grows permanently. These damages are very alarming due to the fact that the monuments and works of art represent irretrievable treasures of artistical and historical cultural originality. They are in extreme danger since the continuously changing conditions of moisture, temperature, and *pressure act in combination with* pollution influences like SO_2, NO_x, CO_2 etc. This leads to chemical and physical processes that produce shearing forces in the heterogeneous stone material. The great number of environmental stress cycles may finally be responsible for the genesis of irreversible damages such as cracks or fracture. Such damages, for example, can be seen in fig. 1.

Figure 1. Damages like cracks and spalled regions at a Christ statue in Oberplaichheim, southern part of FRG. (Photograph by IBACH Steinkonservierung, Remscheid, FRG).

The investigation of the deterioration processes is of great importance to develop suitable methods of preservation and protection to prevent further decay. To study the dynamics of stone deformation electronic speckle pattern interferometry is a distinguished *real-time* method which allows non-destructive measurements in the order of magnitude of one wavelength of the illuminating light used.

2. PRINCIPAL CONFIGURATION FOR DEFORMATION MEASUREMENTS BY ESPI

When the rough surface of a natural stone sample is illuminated coherently, a speckled image is formed, which is characteristic of this surface. Deformation of the surface causes an according shift of this pattern. To measure changes of the order of one wavelength requires the superposition of a reference wave for *out-of-plane displacements* or the use of two illuminating wavefronts for in-plane displacements[1]. The resulting intensity pattern of

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Application of holography and ESPI techniques to earthquake prediction

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ABSTRACT

The laser holography and ESPI techniques are used for directly measuring crustal deformation in terms of fringe displacements in the interference pattern. These techniques will be useful to predict occurrences of destructive earthquakes.

1. INTRODUCTION

Since shallow earthquakes are most probably due to sudden release of strain energy accumulated secularly in the Earth's crust, continuous measurements of strain accumulation in seismically active regions are essentially important for the earthquake prediction. Over the last half a century, the geophysical strainmeters so called extensometers have been widely used for measuring strain changes caused by tectonic and tidal forces and seismic origins. Now, we attempt to apply the techniques of holographic interferometry and ESPI (electronic speckle pattern interferometry) to measure the crustal deformation quantitatively for the purpose of the earthquake prediction in Japan and studying the related geophysical subjects.

The conventional extensometer, in which a length of solid rod is used to measure the relative displacement between two piers fixed into the bedrock, can detect only one component of the Earth's motion, i.e. a linear strain between two points. On the contrary, the use of holographic interferometry or ESPI has the merit of detecting two- or three-dimensional strains simultaneously, of the order of the wavelength of the laser light. Moreover, these methods allow us to measure a small strain directly without contacting the object. The advantage of this is to be free from some of problems inherent in the conventional extensometers using solid materials such as the fused quartz tube or the super-invar bar. In these cases, it has been necessary to consider the effects from the frictional forces between the solid materials and their supports as well as the deformation of the materials themselves.

In the geophysical sciences, the laser holographic interference technique has been successfully used for measuring rock deformations in laboratory experiments.[1,2] It is, however, difficult under ordinary circumstances to obtain a hologram of a large object of more than 1 m because of environmental perturbations caused by atmospheric changes and artificial noise. Thus, strain measurements with holographic interferometry have been commonly carried out using small objects which have a dimension of 10 cm or so. In order to overcome this difficulty, we installed a holographic recording system in a deep tunnel where the temperature change was negligibly small and artificial noise did not exist. If an adequate laser source is provided for the system, holograms of large objects of more than 1 m could be obtained under the same conditions. Moreover, the tunnel wall itself is considered to be an object for holographic interferometry. Thus, the tunnel deformation caused by tidal and tectonic forces can be detected by analyzing the fringe displacement of the interference pattern.

2. HOLOGRAPHIC RECORDING

In 1984,[5] a laser holographic recording system consisting of a 50 mW He-Ne laser and associated optical elements was installed in the observation tunnel at the Amagase Crustal Movement Observatory, Kyoto, Japan, in which the various types of strainmeters and tiltmeters were installed and continuous measurements of crustal deformations using these conventional instruments have been carried out since 1967.[4] As shown in Fig. 1, the observation tunnel has a length of 1830 m and a gradient of 1/1300. The section of the tunnel has a horseshoe shape, with a diameter of about 6 m. The laser holographic recording system was installed at 320 m from the entrance of the tunnel and 130 m below the surface. The annual variation of temperature at that position is about 0.2 °C and its daily

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<u>Interferometric Studies of very hot Objects
by use of TV-Holography (ESPI)</u>

J.T. Malmo

(Manuscript Due)

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Measuring Rotating Component In-Plane Strain using Conventional Pulsed ESPI and Optical Fibres

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ABSTRACT

Pulsed laser ESPI provides a non-contact method of in-plane strain measurement on rotating components. Engineering problems over a wide range of speeds up to 12,500 r.p.m. and tangential velocity of 150 ms^{-1} may be analysed. Illumination via optical fibres removes the problem of components with limited optical access.

1. INTRODUCTION

The ESPI technique pioneered at Loughborough University [1] for in-plane displacement measurement on static components has now become an established technique for the measurement of component deformation. Significant developments have extended its application to out-of-plane and in-plane displacements under dynamic conditions. The development of the technique for the analysis of in-plane displacements on rotating components has been carried out at The City University.

The narrow pulse width of 20 ns for the pulsed laser freezes the component motion. Two beam oblique illumination of the component surface gives a displacement sensitivity direction in the plane of the illuminating beams. Clear high contrast interference fringe patterns may be achieved using high resolution TV equipment and electronic subtraction of the speckle images of the component surface. Providing an initial state speckle image may be recorded and subsequent live load images are available subtraction fringes may be produced over a very wide range of component speeds. Conventional optics give a satisfactory area of fringe information up to component speeds of 5,000 r.p.m. and tangential velocities of 60 ms^{-1}, and the use of twin cylindrical mirrors have extended this to more than 150 ms^{-1}.

The introduction of a high resolution TV system sensitive to low light levels improves general fringe quality and contrast. Where previously all component surfaces were painted with matt white paint, now simple machined surfaces are found to scatter sufficient light towards the camera. This widens the range of application to compor nts where painting the surface is not possible. Tests on automobile brake disc components gave satisfactory fringe patterns. Use of a macro-zoom lens also shows that the system displays significant depth of focus so that non-plane components may be included.

Preliminary tests using fibre optics have been carried out to assess the possibility of their use in regions of limited optical access. Although the use of pulsed lasers in conjunction with fibre optics may cause fibre damage previous experience has shown that only a small proportion of the expanded laser output is actually utilised in illuminating the component area of interest. Numerous alternatives in the use of fibre optics may be possible including fibre optic arrays over large areas of interest or greater location precision in illuminating small areas of interest by single fibres or the use of di[illegible] lasers in place of the pulsed [illegible]ser.

ELECTRONICS EQUIPMENT

The use of pulsed lasers for the analysis of dynamic problems requires the precision triggering of the laser Q-switch to give the correct register of the two speckle images of the component surface for subtraction to achieve good interference fringe patterns and avoid decorellation. The triggering system already reported [2] operates successfully over a wide range of component speeds although some modifications are anticipated to suit particular applications.

The high resolution TV equipment currently in use gives improved contrast interference fringe patterns for components painted with matt white paint and allows satisfactory patterns to be recorded from untreated machined surfaces. The application of fibre optics in the system would require no major change to laser trigg[illegible] or TV camera apart from the provision of fibre or borescope for image retrieval through component casings or in regions of restricted access.

OPTICAL SYSTEMS

The conventional plane mirror optics, Figure 1, and more recently the twin cylindrical mirror system, Figure 2, has extended the possible speed range of application of pulsed ESPI. Components rotating at speeds in excess of 12,500 r.p.m. and tangential velocities of 150 ms^{-1} yield clear interference patterns, which is far beyond the original suggested limitation of 2 ms^{-1} [3]. This is made possible by the introduction of the twin cylindrical mirror system [4] which provides radial illumination of the component and hence radial sensitivity throughout. This removes the sensitivity to components of tangential velocity parallel to the component diameter, causing fringe "blurring out" at velocities above 5 ms^{-1} for the plane mirror

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Three-dimensional vibration analysis using electronic speckle pattern interferometry (ESPI

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ABSTRACT

ESPI is an established analysis technique, offering the benefits of non-contact, ful field resolution and real-time observation. It has previously been used in ma applications for analysis of out-of-plane vibrations and in-plane strains. In this pap it is shown that a combination of out-of-plane and in-plane sensitive ESPI arrangements c be used to measure the vibration amplitude of an object in three independent orthogon components. These results can then easily be interpreted to determine the full thre dimensional mode shape. The method is demonstrated by observing volume vibrations of thick hollow cylinder. Experimental results are compared with finite element prediction enabling the mode shapes to be easily identified and analysed.

1. INTRODUCTION

As engineering structures become more complex and their design specifications beco more stringent, there is an increasing need for detailed knowledge of their vibrati behaviour. Hence there is a need for more sophisticated analysis techniques, yieldi complete information easily and accurately. Work is currently being carried out Loughborough University, in collaboration with industry, to develop a comprehensi vibration analysis package combining three techniques: Finite Element Modelling (FEM modal analysis by accelerometers, and Electronic Speckle Pattern Interferometry (ESPI Part of this work has been concerned with developing ESPI to observe and measure the fu three-dimensional vibration modes of a structure. This paper summarises the results far, and discusses the potential for future analysis systems.

Most experimental vibration analysis methods only measure motion in one directio Strain gauges measure one component of in-plane strain, but more often out-of-pla (transverse) vibrations are measured. This can easily be achieved using convention accelerometers, or optical methods such as holographic interferometry (HI) or ESPI. The techniques have been used in many industrial applications, examples being the observati of resonant modes in turbine blades[1] and in automotive engine blocks[2]. When consideri the lower order resonant modes of thin sections, this is often sufficient to ful characterise the mode shape. However at higher frequencies and in more complex object modes occur which involve in-plane (lateral) components, such as torsional or stretchi modes. Structures with thick sections or irregular surfaces may exhibit combinations in-plane and out-of-plane vibration even at relatively low frequencies, whilst oth components such as sonic resonators may be specifically designed to have resonant mod which are predominantly in-plane on some surfaces. In these situations it is necessary be able to measure the vibration in three dimensions in order to gain a full understandi of the mode shape.

One method of measuring three-dimensional vibrations is to use triaxial accelerometer however, this method has several disadvantages. An accelerometer can only measu vibration at a point, so to obtain the mode shape of a structure readings must be taken a grid of points across the surface. As frequency increases the distance between nodal a antinodal regions decreases, necessitating the use of a finer grid to ensure adequa resolution. For large structures or complex modes the number of sites required can easi be in excess of 100. Consequently the time needed to take all the readings can considerable, for example, typically three months for full analysis of an engine bloc Also, the added mass of the accelerometer is bound to affect the vibration characteristi of the object, and in some situations this can be significant. Finally, surfa accelerations at ultrasonic frequencies are extremely high (upwards of 1000 g), and th can make attachment of accelerometers difficult.

Optical techniques can be used to overcome some of these problems, one of the bett known being holographic interferometry (HI). This has the advantages of being no contacting, so that the object vibration is not affected, and of giving information over entire surface in one view. The information is in the form of bright and dark fring superimposed on the image of the test object, which correspond to contours of consta amplitude components resolved along a single sensitivity vector. The vector general gives sensitivity to a combination of in-plane and out-of-plane components, but it is n possible to obtain three mutually perpendicular vectors for a given view. Hence

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Developments in Electronic Speckle Pattern Interferometry for Automotive Vibration Analysis.

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ABSTRACT.

The incorporation of monomode fibre optics into an argon ion powered Electronic Speckle Pattern Interferometer (ESPI) is reported. The system, consisting of an optics assembly linked to the laser and a CCD camera transceiver, flexibly connected by 40m of monomode fibre optic cable to the optics, has been used to analyse the modal behaviour of structures up to 5m X 3m X 2m in size. Phase modulation of the reference beam in order to operate in a heterodyne mode has been implemented using a piezo-electric crystal operating on the monomode fibre. A new mode of operation - sequential time-average subtraction - and the results of a new processing algorithm are also reported. Their implementation enables speckle free, time-average vibration maps to be generated in real-time on large, unstable structures. Example results for a four cylinder power unit, a vehicle body shell component and an engine oil pan are included. In all cases the analysis was conducted in a general workshop environment without the need for vibration isolation facilities.

1. INTRODUCTION.

Electronic speckle pattern interferometry (ESPI) has become established as an important optical technique in a range of engineering applications, chiefly for vibration studies[1]. However, the technique demands a relatively complex optical arrangement (Figure 1) which must be maintained in very precise alignment throughout the experiment. Furthermore, when using an argon ion laser in the system, in order to analyse large objects, considerable rearrangement is required whenever the field of view is changed. It is common in these experiments for the entire experiment to be conducted on a vibration isolated optics table, to which the test object is rigidly mounted. These requirements have tended to restrict the applications of the technique.

We report here a development of ESPI in which many of the conventional optics are replaced by optical fibres and related components. The laser source and other precision components are separated from a compact transceiver which contains optics for object illumination, the camera and reference beam optics. The source and transceiver are connected by a flexible optical fibre cable. The transceiver is robust, requires minimal alignment and may be operated outside the benign environment of the laboratory. It may be traversed readily, or used to inspect different objects in rapid succession without readjustment. We have used an argon ion laser source giving an object beam power of typically 500mW, so that the system may be used with long working distances to acquire, very rapidly, vibration maps of large objects (>10m^2). Experiments have been conducted with fibre optic cables up to 40m in length.

LASER TECHNOLOGIES IN INDUSTRY

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OPTICAL METROLOGY

Holographic Optical Elements

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Visible and Near-Infrared HOE

C. Liegois

(Manuscript Due)

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Laser beam shaping by computer generated holograms

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ABSTRACT

In this paper, we describe a method and a system to transform a laser intensity gaussian distribution into a uniform distribution. We use computer generated digital holographic filter. We explain the modelisation, *the production and the way of use of* these filters.

INTRODUCTION : STATE OF THE ART

For many application, it is necessary to reshape a laser beam to have as a uniform as possible intensity distribution. A large amount of papers were published on this topic. The TEMoo laser beam *has to be "flat" when it is used in metrology,* computing, or material processing. Classical methods as they are proposed by Harton and MC Dermit (1) propose a combination of lenses and reflectors to transform the gaussian shape of the beam into a feat uniform repartition.

For nuclear fusion and superficial material processing, Lacombat et al (2) describe a method in which the gaussian laser beam is splited in four parts that are combined on the target zone, this process gives to the laser *beam an approximatively uniform shape.*

For some radars using a laser, Veldkamp et al. (3,4,5) use a diffraction pattern to obtain a uniform distribution in the laser beam. In optical processing and optical metrology, a collimated beam with a flat profile and a uniform phase is often necessary (6). For this purpose, generally the laser beam is expanded with a microscope objective with a high magnification ratio, a spatial filter and a collimating lense are added. Th (7) describes a way of *expanding the beam* without using a microscope objective. He uses a neutral absorbtion glass to produce a complex collimating system. This system transforms a gaussian beam in an homogeneous flat beam with an efficiency of 37 %. Rhodes and Shealy (6) use an afocal system composed of two aspherical lenses in order to obtain an almost flat and collimated beam with a high efficiency. *This system is very difficult* to realise. Shafer (8) combines an afocal system with 4 spherical lenses. The uniform profile is realised by compensation of the spherical aberration of the four lenses.

In summary, we can say that gaussian coherent beam shaping can be achieved by absorbtion (7), by a reflecting or a refracting (1) or a diffractive (3,4,5) or a segmentation (2) process. All these methods have advantages, but also and mainly incovenients that lead to a non use of these methods in practical cases *where they will* be necessary.

We propose two *usable methods to turn a gaussian* beam into a rectangular profile beam by using computer generated holograms.

2. DESCRIPTION OF THE TWO METHODS

The first method and system (fig. 1) utilise the spatial frequency of the object. The object being the gaussian collimated beam in a P plane that can be modified by a spatial filter hologram in the H plane *to produce a filtered image* (uniform beam) on Pi plane. The hologram will be realised with the Brown and Lohmann method (9). These holograms have a binary architecture.

The second solution gathers two phase holograms into an afocal system *that will have* the same operational advantages than the Rhodes system (6). As we see in Fig. 2, the first hologram is used to bend the beam in order to transform the gaussian repartition into a uniform beam. The second *hologram is used to collimate* the uniform beam.

3. THEORY OF THE HOLOGRAPHIC FILTER THAT WE USED

Let's consider a linear coherent optical system as we can see in *Fig. 1.* We determine the connection between the wavefronts Po and Pi by the equation :

$$R(u, v) = G(u, v) \, . \, H(u, v)$$

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Silver halide sensitized gelatin as a holographic storage medium

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ABSTRACT

Silver halide sensitized gelatin is one of the most promising techniques for the manufacturing of transmision holographic optical elements. These techniques combine the relatively high sensitivity of photographic material with the low scattering and high light-stability of dichromated gelatin. The influences of the developer and the bleaching in the difraction efficiency and noise is analized starting with Agfa 8E 75 HD plates.

According to P. Hariharan,[5] we analized the processing steps and this show that the developer action influences on the noise level and the modulation transfer function. The developer of the type PAAP produces better resolution and less noise level than the developer D-19.

The bleaching action is related to the difraction efficency and the hardering level of the gelatin. The hardering action is promoted by trivalent chromium ions which are generated in the vicinity of the oxidized silver grains and controled by the ratio concentration to the Cr^{+3} ions and Br^- ions of the bleaching bath. The measurements of the difraction efficiency in the different steps of the processing give us information about the mechanism of hologram formation.

1. INTRODUCCION

Silver-halide sensitized gelatin is a processing technique which combines the energetic and spectral sensitivity of photographic emulsions with a high diffraction efficiency and the low level of noise of dichromated gelatins.

The technique was initially developed by Penington, Harper and Laming,[1] though the technique in its present day state is due to the works of Graver, Gladden and Estes[2] on the one hand and to those of Chang and Winick[3] on the other.

One of the problems involved in this processing technique lies in the fact that the resolution power is dependent on that of the photographic emulsion. Ferrante[4] has studied this aspect closely and has found a significant decrease when we get to 2000 l/mm. Hariharam,[5] in his turn, has analysed the influence of the developing, whereas Angell[6] has recently optimized the processing for the Kodak 649F emulsion.

In this work we are going to show the results we have obtained for the Agfa 8E75HD emulsion, these being based on a modification in Chang and Winick's processing for this technique and on Chang's[7,8] results with dichromated gelatin.

2. PHOTOCHEMICAL PROCESSING

On table I are shown in detail all the stages in the processing of 8E75HD plates.

For its development we built up holographic diffraction networks between 1000 and 2000 l/mm, which we obtained in a conventional holographic device of symmetrical geometry, by using a He-Ne laser.

Once the photographic emulsion has been exposed it is developed and then bleached. Due to the action of the bleacher the developed silver is oxidized to Ag^+, whereas the the Cr^{+6} ion is reduced to Cr^{+3} during the same bleaching wash. This way the Cr^{+3} ion is linked to the gelatin chains in the vicinity of the oxidized silver grains achieving a variation of hardening between the exposed and nonexposed zones of the emulsion.

The emulsion is then fixed to remove all the excess silver halides. The processing is completed with the washing of the emulsion and its dehydration through successive baths in isopropanol, following a processing similar to that of a dichromated gelatin.

With this classic processing we achieve a 50% diffraction efficiency for networks with the 8E75HD emulsion, a worse result than the one obtained by Angell. From our point of view, this drop is due to the fact that the degree of hardening that is reached in the 8E75HD emulsion gelatin is not the right one, if we compare it to that of the 649F emulsion[6]

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Laser interferometric method for the measurement of film thickness, using holographic optical components

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ABSTRACT

An interference method for determination of the thickness of thin dielectric films deposited on metal substrates is described. The method uses the variation of multiple-beam interference of light reflected from the sample as the incident angle is changed. The effects of the phase change on reflection at the metal/dielectric interface are shown to be negligible for a MgF_2 film deposited on Chromium. A working instrument is described which uses holographic lenses to obtain the large scan angles required with low aberration. The results obtained with this instrument agree well with those obtained using a Talysurf.

1. INTRODUCTION

Measurement of the thickness of thin dielectric films in the range from one to several tens of micrometres is of importance in the semiconductor and polymer industries. Whilst various absorption-type sensors are currently used for monitoring films in this thickness range, the use of more elegant techniques such as ellipsometry and interferometry is relatively uncommon. Ellipsometry can only cover a relatively small range of thicknesses, and although white light interferometry with Michelson-type interferometers has been used for the measurement of epitaxial layer thickness in the semiconductor industry, it is inconvenient in that it is often necessary to determine absolute fringe order by spectral analysis[1].

In this paper, we describe a method for the determination of film thickness in which the ... light reflected from the front and back surfaces of the film is ...

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Construction of holographic mirrors in dichromated gelatin

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ABSTRACT

A method for the construction of high efficiency, narrow spectral and angular bands and low dispersion and absortion holographic mirrors is described. The relevant physical and chemical parameters on the several stages of the production of the hologram regarding the final quality have been studied one by one. Several development temperatures have been carried out. The comparison between those methods is done by the analysis of the final optical mirror properties. Rutherford Backscattering has been used to measure the thickness of the film of gelatin. Some results are presented and the method is discussed.

1. INTRODUCTION

Dichromated Gelatin is a promising photosensitive medium that can hold holograms with high diffraction efficiency, while keeping the holographic plates transparent.

To control simultaneously these two characteristics is the most important difficulty in the use of such material. The best compromise between both depends on the kind of hologram to be done.

The measure of the thickness of the gelatin layer is critical for reproducibility and to check results with Kogelnick theory.

In this paper we will discuss how the pre-hardening affects the diffraction efficiency and how the angular bandwith dep('s on the exposure.

We suggest how Rutherford backscattering can be used to measure the thickhness of the gelatin layer, present some results obtained and discuss some limitations and the accuracy of the method.

2. CONSTRUCTION OF HOLOGRAPHIC OPTICAL ELEMENTS (HOE's)

Holographic Optical Elements (HOE's) require several steps to be followed.

The first one is the preparation of the gelatin: a mixture of water and solid gelatin is heated until complete dissolution. Some dichromate is added for hardening purposes and after filtering the solution can be deposited on a glass plate. The plate dries at room temperature for about 12 h and then (in a gel state) is heated for 2 h at 120° C, thus hardening the gel.

In the sensibilization step, the hardened gelatin film is imersed for a few minutes in a solution with 5% of amonium dichromate and left to dry. The plate is now ready for exposure.

The development consists in the following procedure:

1 - 10 mn under current water (23° C)
2 - 3 mn in a solution with 25% propanol-2 (23° C)
3 - 3 mn in a solution with 50% propanol-2 (23° C)
4 - 3 mn in a solution with 90% propanol-2 (23° C)
5 - 15 mn in 100% propanol-2 (80° C)
6 - drying with a flow of heated air .

3. ON THE RELATION BETWEEN DIFFRACTION EFFICIENCY AND PRE-HARDENING

In the construction of holographic optical elements, mirrors or lenses, transparency of the HOE is a fundamental need. The amount of amonium dichromate (DC) necessary to harden the gelatin is the main chemical parameter that has been studied. The experiments carried out with reflection plane holograms showed that for development at room temperature there are two important concentrations of dichromate which seem to lead to different behaviour of the HOE.

With 0.5% DC the plates show two different zones after development : in the non exposed area the optical noise is visible, in the form of milky haze; in the exposed area the plate is clear. Bellow 0.5% DC concentration there is optical noise even in the exposed areas. This behaviour shows that 0.5% DC seems to be an important turnover for the hardening concentration.

Behond 0.6% DC the diffraction efficiency of the hologram is quite sensitive to development conditions and lower exposures may lead to higher efficiencies.

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Development and Manufacturing of an Integrated Miniaturized Holographic Laser-Doppler Optics

G.S. Stojanoff

(Manuscript Due)

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COUPLING EFFICIENCY IN A HOLOCOUPLER-OPTICAL FIBER SYSTEM

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ABSTRACT

We present a mathematical model based on the eikonal approximation for the diffraction of a TM wave by an optical fiber with parabolic profile. Optimal conditions for the signal to be totally confined into the fiber have been studied and numerically controlled. The light coupler was a hololens acting as a holocoupler. The total coupling efficiency of the system has been estimated for particular physical parameters.

1. INTRODUCTION

In the design of particular optical and opto-electronic systems were optical fibers are required, the connection between neighbouring fibers is sometimes necessary. For that purpose specific systems are required to ensure an optical connection with maximum coupling efficiency. An interesting alternative to conventional couplers is based upon the properties of holographic gratings as holocouplers[1]. This one appears to be a dispositive presenting quick transmission, high capability for storing information in short space as well as high efficiency. The efficiency of the coupling, describing the percentage of luminous energy stored into the fiber depends upon the register conditions and the optical and physical parameters of the fiber. The total efficieny is defined as the product of the transmission efficiency of the hologram, η_H, times the intrinsic fiber efficiency, η_i, then, values of the order of 0.25 were found for the holocoupler system, ($\eta_H \times \eta_i$ = 0.65 X 0.39). A first holographic theory and a classification of the factors to be considered in the optimization of a holocoupler were formulated by Soares[2]. Several physical parameters appear to influence dramatically the coupling efficiency. Namely, polarization state, wavefront aberration, lateral and angular shifts, thickness variation. Recently, it has been predicted theoretically a loss of a 25% of the processed energy at the zero spatial frequency of the MTF of a hololens/parabolic optical fiber system[3].

We have introduced a mathematical model by establishing an inequality leading to the coupling condition in a hololens/optical fiber system and to the definition of an intrinsic coupling efficiency for the fiber. Numerical estimates have been made for the coupling condition by studying the variations introduced in the obtained expression with respect to several physical parameters influencing the amount of energy captured by the optical fiber. Those parameters are, in particular, the polarization state of the reference wave, the angle of incidence of the same, the distribution of the parabolic profile for the refractive index of the optical fiber and the absorption coefficient of the hologram.

2. COUPLING CONDITION IN A HOLOLENS/OPTICAL FIBER SYSTEM

We have made use for the purpose of developing our mathematical model the experimental set up shown in Figure 1 for the register of a holocoupler[2]. In general, the holographic coupler is an interferogram formed as follows: 1) The first hologram H_1 located in plane $z = z_1$ is recorded with the output beam of fiber 1 located in plane $z = 0$, and, the incoming reference beam considered as a plane monochromatic wave.
2) The second hologram H_2 located in plane $z = z_2$ is recorded by the output beam of fiber 2 located in plane $z = d$, and, the conjugated of the reference wave to make the coupling easier.

In the best coupling conditions, if we reconstruct with the output of fiber 1, then, the light is transmitted and focused into fiber 2 under strict confinement conditions as it is shwon in the figure.

We are interested in studying and describing the signal in the X_2 axis defined at the aperture of fiber 2 There, we shall make use of the mathematical expression for the scattered signal under eikonal approximation. We notice that the system is reciprocal and the same can be done in the aperture of fiber 1.

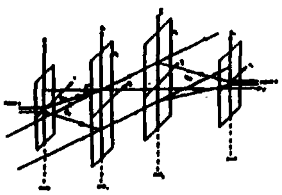

Figure 1. Holographic coupler: schematic representation of the experimental set up for the register

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LASER TECHNOLOGIES IN INDUSTRY

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OPTICAL METROLOGY

LASER SURFACE INSPECTION

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Software techniques for the analysis of contour maps of manufactured components

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ABSTRACT

The image processing of contour type fringe patterns to extract coordinate information well understood. This paper discusses the further processing of this information in der to determine the fundamental geometrical nature of the underlying surface. rticular reference is made to the use of such analysis techniques for industrial spection of surface form.

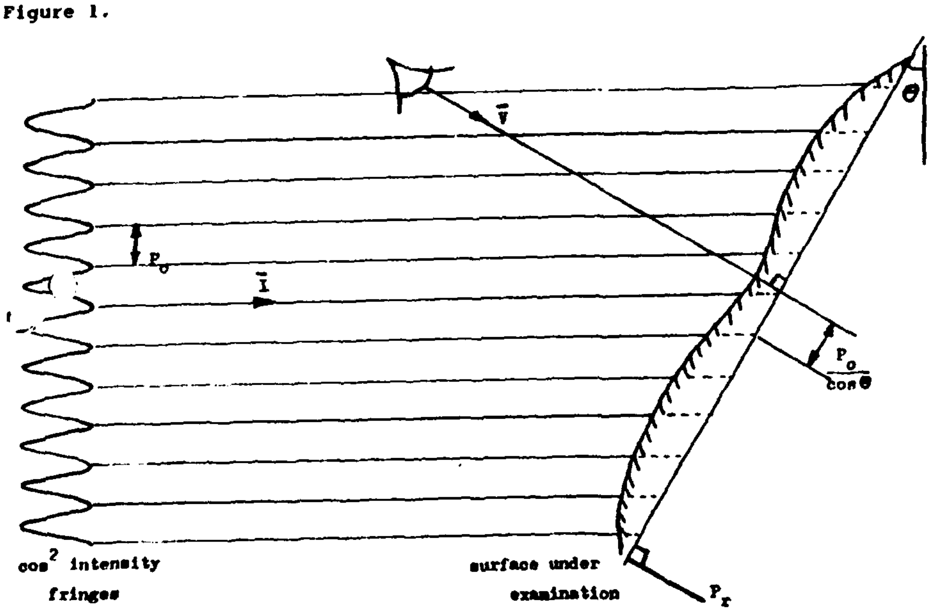
1. INTRODUCTION

The use of light fringes to study, at least qualitatively, the small deformations or anges in specularly reflective surfaces is well understood[1,2,3]. The extension of these chniques to the study of what might be termed the underlying macrogeometry of the object self via the creation of 'contour maps', while less well known, is still a well velo technology[4-7].

The authors have for a number of years employed a wide variety of contouring techniques the development of high precision industrial, non contact, surface form measurement struments. Methods used include:

) dual index and dual frequency holography[4,5]
.) interferometric fringe projection[6], and
.i) Ronchi or $\cos^2$ grating shadow projection[7].

basic measurement philosophy of all of these techniques can be explained by reference Figure 1.



ure 1. General arrangement of projection contouring

In this arrangement, which is basically a fringe projection system, the constantly ced $\cos^2$ intensity fringes impinge on the surface under inspection from an illumination ection given by the vector $\bar{I}$. The resulting fringe pattern is then viewed from an -axis direction shown by the viewing vector $\bar{V}$.

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Surface Quality Assessement by Laser Technique

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L. Fabbri

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(Manuscript Due)

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Mechanical Design Considerations in Scanning Optical Microscopy.

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ABSTRACT

We review the choice of scanning mechanisms for scanning optical microscopy and discuss the factors which make certain approaches more attractive.

1.0 INTRODUCTION

The acceptance of scanning as an attractive attribute to optical microscopy is relatively recent in the sense that scanning *optical* microscopes have only become commercially available in the last few years. Interest in scanning has always been alive in the biological and semiconductor physics fields where the use of a scanning beam to excite certain processes has generated useful information. However, it was not really until the development of the confocal scanning optical microscope [1,2,3] and the relatively cheap availability of powerful computer processing that the field really came alive. It is now common to find entire conferences devoted to the subject [4,5]. However, it is not common to find much discussion of the choice of scanning mechanism employed. In the following, therefore, we choose to discuss the choice of scanning technique rather than the multitude of unique image formation modes and computer processing which these systems lend themselves readily to.

2.0 THE CHOICE OF SCANNING METHOD.

A confocal scanning microscope is shown schematically in Figure 1. Although this scheme is shown in transmission, which is an uncommon practical arrangement, the key elements are clear. They are some form of electrical/computer control of the scanning mechanism and signal/picture analysis and display. The use of a point detector ensures confocal operation [1,2]. We clearly need to scan the light beam relative to the object in order to form an image and so we have the following alternatives

- Scan the object.
- Scan the objective lens.
- Scan the light beam.

or, to be complete, a combination of any two of these. It is also desirable for some of the confocal imaging modes to be able to scan the object axially [2]. We will now discuss the merits of the various schemes and their suitability for incorporation in scanning microscopes built around conventional microscopes. The merit of such an approach is that the region of the object of interest can quickly and easily be found before the more specialised and sophisticated techniques of scanning microscopy are employed.

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Automatic Surface Analysis of Projection Interference Fringes

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Abstract

Projection fringe interferometry techniques were used together with an automatic surface analysis algorithm to construct three-dimensional topographic maps of a nonoptical surface. Parameters determined by the algorithm include: average surface roughness, surface height distribution descriptors and the autocorrelation function. The resolution of the system can be varied from submicron to millimeters in both lateral and vertical directions. Results are presented for a surface analysis of an oxidized roughly cut block of iron. They were found to be in good agreement with measurements obtained via the stylus profilometer method.

I. Introduction

Nondestructive on-line optical techniques provide a very useful method for measurement of surface roughness during inspection procedures. Among the various types of methods one can use i.e. light scattering, speckle, etc., we shall concentrate on the projection fringe technique. This method allows one to obtain a three dimensional topographic map of a surface. Resolution of the surface structures can be varied from the submicron to the millimeter range in both lateral and vertical directions. The method also lends itself to analysis of nonoptical surfaces in which the surface reflectivity is not very strong.

Projection interference fringes are produced on a surface to be inspected by lowing two coherent beams of light to intersect on the area to be examined. The projected straight line fringe pattern becomes deviated wherever there is a surface deviation. The contoured fringes thus produced are then digitzed via an on-line vidicon and recorded in a microcomputer. An important point of the analysis is the type of algorithm used to analyze the interferogram. We have developed an automatic tracking algorithm which tracks the fringes and outputs statistical parameters which describe the surface topographic map, [1-11].

II. Interferogram Construction

The intensity in the volume of intersection of two collimated laser beams projected onto a surface to be inspected is given by,

$$I(\vec{x},t) = c \in |\vec{E}|^2 \{1 + \cos[(\vec{k}_1 - \vec{k}_2)\cdot\vec{x}]\} \qquad (1)$$

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Revised Version

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Surface Inspection of Laser Treated Materials via Three Dimensional Computer Color Contouring

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ABSTRACT

The inspection of laser treated materials is performed via use of a microcomputer on-line to a digitizer which records the interferogram produced using projection interference techniques. The burning was performed via a high powered pulsed industrial carbon dioxide laser. The resulting burns varied in quality over the two surface dimensional. Surface micro-structures were analyzed using the recorded interferogram. Special image processing algorithms were developed to extract the burn features from the surrounding background.

Results are presented depicting variations in the burns. They reveal the quality of the laser pulse and its effect on different areas of the alloy. Lateral and depth resolutions of the order of a few microns were achieved. A topological mapping of the burns is presented as a three dimensional color contour of the surface.

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Surface Roughness Measurement by

Speckle Processing in a Defocused Plane

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(Manuscript Due)

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Mapping of Textile Surface Relief

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ABSTRACT

We describe a system which is capable of mapping the relief of textile surfaces, by non contact optical means, designed to be used in *textile engineering laboratories* to study the alterations produced in fabrics by the action of *dyes*, *shock*, *stress*, and *so on*. The specific nature of these materials precludes the use of conventional profiling systems, which led us to develop a new method with the *necessary versatility* but reasonably immune to dispersion, diffraction and speckle, phenomena which usually make very difficult the application of optical methods to this situation.

The method is based on the horizontal shift of the bright spot on an horizontal surface when this is illuminated with an oblique beam and moved vertically. In order to make the profilometry the sample is swept by an oblique laser beam and the bright spot position is compared with a reference position. The system is thus formed by an HeNe laser focused onto a reference surface (sample support) endowed of bidirectional motion obtained by two stepping motors which are controlled by a 8051 microcomputer that will also control the data *acquisition and processing system*, and *it's forwarding to the working microcomputer*. The laser beam incidence angle, the focusing system and the reception objective can be changed to increase the system fickleness.

1 INTRODUCTION

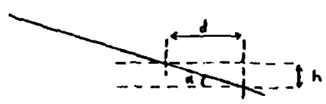
The consumers increasing exigence and the strong competition impose the industrial companies (and production investigation laboratories) a better knowledge of raw material physical characteristics. So, we have been requested to develop a textile surface relief mapping system by non contact means, in order to study texture alterations produced in fabrics by the action of dyes, stress, and so on.

2 THE METHOD

When an horizontal surface is illuminated with an oblique light beam and moved vertically, an horizontal shift of the bright spot will occur.

The profilometry is achieved sweeping the sample with an oblique laser beam. The bright spot horizontal shift, in respect to a reference position and amplified by the reception optical system (ROS), is recorded in the microcomputer memory for later analysis.

The relationship between the vertical shift (h) and the horizontal one (d) is:



$$\frac{h}{d} = \tan\alpha$$

The amplification factor will be greater for lower incidence angles (α) at the expense of a bright spot area enlargement which can be very inconvenient namely for irregular surfaces. So the incidence angle must be moderate depending on the kind of surface (between 20° and 50° for most common fabrics). The horizontal shift amplification will be done mostly by the reception optical system (ROS).

3 THE SYSTEM

The system (fig. 1) is formed by an HeNe laser (1) (NEC: GLG 5210; 632,8nm; 1mW); attached to a structure (2) which allows changes in the laser beam incidence angle; an adjustable incidence optical system (IOS), formed by a filter and a convergent lens (3); the sample support (4) (reference surface Precimove 100, Indufer) endowed of bidirectional motion provided by two stepping motors (Superior Electric: SLO-SYN; M061) controlled via Modulinx motion control system (Superior Electric) by the automatic data handling system (ADHS) (5) based on a 8051 microprocessor; an adjustable ROS (6) (x 10 objective) attached to a video camera (7) (SONY HNS-14; CCIR standards).

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Eddy Current Nondestructive Evaluation of Laser Glazed Metallic Surfaces*

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ABSTRACT

Laser glazing holds great potential for the production of new and improved materials, but there is a need to identify and control the thickness of the glazed layer and to monitor porosity and other defects in the surface layer and adjacent substrate by using nondestructive evaluation techniques. Eddy current methods rely on the interaction of electromagnetic fields with the metallic part under test, which effectively transfers the impedance of the test specimen to the excitation coil so that changes in the test specimen which affect the transferred impedance may be detected by the test coil. This paper addresses the experimental parameters of laser glazing of metallic surfaces, eddy current probe suitability for reliable measurement of thin layers, ranges of operating conditions, sensitivity, speed of response and feasibility of eddy current nondestructive sensors for use in process control.

1. INTRODUCTION

Laser glazing is the process in which a shallow surface layer of material is melted by a high power laser beam followed by rapid solidification to produce a microcrystalline layer having improved resistance to wear, erosion, corrosion or impact damage. The laser-glazing process holds great potential in the production of new and improved materials for turbines, reactor systems, boilers, heat exchangers, pipes and tubing. Despite its significant advantages, however, laser processing can generate porosity, cracks and irregular boundaries in both the melt region and the adjacent substrate. This paper describes the development of eddy current nondestructive evaluation (NDE) techniques to monitor and control the thickness of the glazed layer and to characterize defects in the surface layer and heat-affected zone.

Eddy current methods rely on the interaction of a time-varying electromagnetic field with the metallic part under test. An excitation coil produces an alternating magnetic field which induces eddy currents in the specimen, and the eddy currents generate their own electromagnetic field which couples with the initial field. In effect, this coupling transfers the impedance of the test specimen to the excitation coil so that changes in the test specimen may be detected by changes in the electrical impedance of the test coil located near the surface of the metal. A proof-of-concept laser-glazing system was developed incorporating an on-line eddy current sensor for process control. The system was used to evaluate the production of laser-glazed surfaces on stainless steels, tool steels and nickel alloys of interest to energy-related industries.

This paper addresses the experimental parameters involved in laser glazing of metallic surfaces, eddy current probe suitability for reliable measurement of thin layers, ranges of operating conditions, sensitivity, speed of response and feasibility of eddy current nondestructive sensors for use in process control. The next section describes the laser glazing of metallic surfaces followed by a brief account of eddy current technology. Experimental results, discussion and technical findings conclude the paper.

2. LASER GLAZING OF METALLIC SURFACES

The interaction between a laser beam and the surface of a metal or alloy is controlled by a number of variables including the wavelength of the laser radiation, the incident power density and the available interaction time.[1] The laser/material interaction spectrum for a high power, continuous wave CO_2 laser is shown in Table I. The interaction time is defined as the time required for the laser beam to traverse one spot diameter. A particular combination of power density and interaction time defines a specific operational regime. The operating regimes range from high power density/short interaction time to low power density/long interaction time. It is not primarily the quantity of energy applied, but the rate and power density at which it is applied, which produces the specific materials-processing effect desired. In order of increasing power density, the various processing effects

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Physical backgrounds of laser inspection of surface roughness

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ABSTRACT

We present the physical backgrounds of contactless optical inspection of (rough) surfaces by means of scattering of laser light from these surfaces.

1. INTRODUCTION

In the final stage of an industrial process one has to assess the quality of the product. In this presentation we shall discuss the physical backgrounds of an example: contactless inspection by scattering of laser light from the surface to be inspected. We are particularly interested in the surface roughness. Examples are polished or machined surfaces like mirrors, roughness of interfaces. Also the inspection of tiny details present in integrated circuits fits into this study. The purpose is to detect flaws during the production process.

The inspection proceeds as follows: laser light is directed onto the surface to be inspected. The reflected field contains information about the illuminated part of the surface. The basic problem is how to translate the scattered field in terms of the surface characteristics. Such an inverse problem can only be solved if the corresponding direct problem can be dealt with: given the shape of the surface, predict the scattered field. The direct problem can only be treated in a rather simple and easy to grasp way when the local radii of curvature are large compared to the wavelength of the incident radiation. In the greater part of this presentation we shall adopt this restriction. We shall briefly comment on the situation where this restriction is no longer true: the inspection of integrated circuits.

We shall review the following approaches:
- scattering from general surfaces: the Beckmann-Kirchhoff regime.
- scattering interpreted from the viewpoint of the Van Cittert-Zernike theorem.
- rigorous scattering theory.

2. SCATTERING FROM GENERAL SURFACES: THE BECKMANN-KIRCHHOFF REGIME

A laser beam with a Gaussian intensity profile is directed onto a surface which we assume to have the following properties (for the sake of clarity of presentation): the surface bounds a perfectly conducting medium, the surface is cylindrical and is given by $z=f(x)$ (the descriptors are chosen parallel to the y-axis). If we choose the polarisation of the incident field along the y-axis we have a truly scalar problem: denoting the incident field by $\psi_{inc}(x,z)$ and the scattered field by ψ_{sc}, we have to solve the following problem: determine ψ_{sc} from the Helmholtz equation:

$$\nabla^2\psi_{sc} + k^2\psi_{sc} = 0 , \qquad (2.1)$$

where $k=\omega/c$ is the wave number in the medium above the surface (here supposed to be vacuum). As the surface terminates a perfect conductor we have

$$\psi_{sc}(x_s,f(x_s)) = -\psi_{inc}(x_s,f(x_s)) , \qquad (2.2)$$

at every point on the conductor because the total field strength is zero on the conductor. Henceforth we will omit the subscript "sc" at ψ because we will only be interested in the calculation of the scattered field. We now introduce the basic assumption of the Beckmann-Kirchhoff approximation[1]: locally the surface may be approximated by its tangent plane. This assumption is reasonable if the local radii of curvature are large compared to the wavelength of the incident radiation. The incident Gaussian beam is given by:

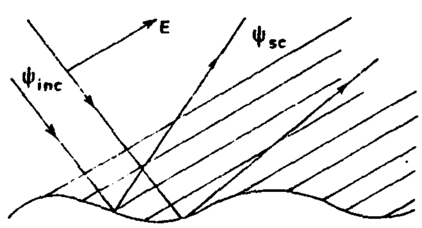

Fig.1: Scattering geometry.

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An Application of Optical Surface Assessment

to Engine Preparation Techniques

K.J. Stout

(Manuscript Due)

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A laser rangefinder for hot surface profiling measurements

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ABSTRACT

This paper discusses the construction and capabilities of a laser rangefinder system for *profiling measurements on hot surfaces (T < 1400 °C), especially measurement of the thickness* profile of the fire-brick sheathing of a converter. The rangefinder consists of an opto-mechanical measuring head, electronics unit and hand-held computer. Special attention is paid to maximizing the inherently low signal-to-noise ratio typical of measurements of this *kind. In addition, an efficient time interval measurement principle is employed which ena*bles rapid determination of a single 3 D point. The measured resolution of the system in a real operating environment is a few millimetres with a measuring time of less than 1 second per measurement point. The accuracy of the system is better than 1 cm in a measurement range of 6 - 17 metres.

1. INTRODUCTION

Many manual measurements are still performed in steel works because of the lack of suitable sensors. The objects concerned are often hot, and non-contact measurements are needed. On the other hand, automation of these measurements would be important to ensure higher quality, higher productivity and less expenditure of work. Safety is also an important factor, especially when working with molten steel.

Distance measurements have many applications in a steel works, e.g. measurement of the level of molten steel in the mould of a continuous casting line, determination of the shape and dimension of hot objects or measurement of the thickness and quality of the sheathing of the converter[1].

Non-contact distance measurement methods make use of various energy beams such as gamma rays, ultrasonic or acoustic waves, microwaves and laser beams. Nuclear systems require extensive safety precautions, and microwave and ultrasonic systems generally show poor bundling of radiation, whereas optical systems have some superior features, e.g. that the light can simply be focused by lenses and the beam can be easily collimated, which enables accurate definition and restriction of the measurement point. In addition, the light beam can be transmitted by optical fibres, which makes it possible to construct optomechanical measuring heads for demanding environments.

This paper discusses the construction and capabilities of a new laser rangefinding system operating on the principle of measuring the transit time required for a very short semiconductor laser pulse to reach the optically visible target and for the reflected pulse to return to a receiver. The instrument can be installed in the roughest of industrial environments in the iron and steel industry. The device is mainly intended for measuring the thickness of the fire-brick sheathing of a converter, although it can easily be employed for distance measurements with respect to other passive objects. The sheathing wears away during the life of the converter, especially around the bottom blow nozzles, and it is important to know its thickness so that maintenance operations can be started at economically the optimum moment in time. The normal thickness of the sheathing is less than 1 m, which thus determines the measurement range per measurement point.

The main problems in this application are the extremely high temperature (about 1200 °C - 1400 °C) and low reflectivity of the sheathing and the relatively long measurement distance of about 10-20 metres. Thus the signal-to-noise ratio (SNR) tends to be low and averaging of successive measurement results is needed to achieve good resolution. The desired resolution and accuracy of the system were specified to be 5 mm (σ-value) and 10 mm, respectively. The thickness of the sheathing is measured using a profiling principle, but the total profiling time has to be short so that the converter is out of production for as short a period as possible. The total measurement time for a single point was specified to be 1 sec.

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Microscopio de projecção de Franjas

J. C. Aparicio Fernandes

O.D.D. Soares

(Manuscript Due)

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LASER TECHNOLOGIES IN INDUSTRY

SPIE Volume 952

OPTICAL METROLOGY

OPTICAL SENSORS

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Integrated Optical Sensors-State-of-the-Art and Perspectives

G. C. Righini

(Manuscript Due)

Laser and OPtical Fiber Sensors:
an overview

Brenci
Conforti

(Manuscript Due)

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Fiber Optic Sensors-Practise and Possibilities

B. Culshaw

(Manuscript Due)

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Pressure sensors based on incoherent diffraction effect

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ABSTRACT

The well known moiré pressure sensor, where one grating is fixed and the other moves with the load, is improved by taking in account the influence of partial coherence effects. Introduction of a specified air gap between the two gratings diminishes drastically perturbations due to parasitical vibrations of mechanical creeping. Use of optical fibers allows a local pure optical measure.

1.- MOIRE FRINGES IN INCOHERENT LIGHTING.

It is well known (1) that two diffractive 2D transparencies f_1 and f_2, situated respectively in planes and n and lighted by a wide incoherent source σ, give in a plane an intensity distribution which depends of the STATES OF PARTIAL COHERENCE.

The theory of partial coherence (2) gives at point Q_3 an intensity

$$I(Q_3) \simeq \frac{1}{l_2^2} \iiiint_{\beta} \Gamma^{(e)}(R_1, R_2, \frac{s_2 - s_1}{c}) dR_1\, dR_2 \qquad (1)$$

where $\Gamma^{(e)}(R_1, R_2, \frac{s_2-s_1}{c})$

is the mutual coherence between the emergent vibrations at points R_1 and R_2 in plane , c the light velocity and s_1, s_2, l_2 the distances represented on Figure 1.

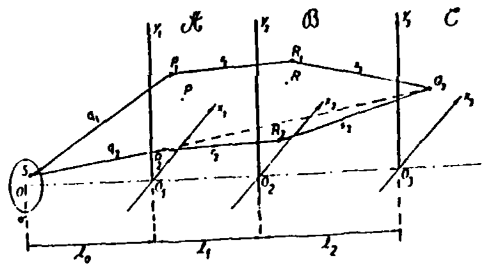

Fig.1.- Moiré fringes in partial coherence.

If $\Gamma^{(1)}(R_1, R_2, \frac{s_2-s_1}{c})$ is the incident mutual coherence at plane we have the relation

$$\Gamma^{(e)}(R_1, R_2, \frac{s_2-s_1}{c}) = f_2(R_1) \cdot f_2^*(R_2) \Gamma^{(1)}(R_1, R_2, \frac{s_2-s_1}{2}) \qquad (2)$$

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On the use of an optomechanical sensing head in time-of-flight laser rangefinding

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ABSTRACT

The time-of-flight (TOF) laser rangefinding technique has recently found many applications for industrial measurement purposes. The electronics of a rangefinder can be separated from the sensing head using optical fibres. In spite of many advantages such as non-sensitivity to demanding environments, optical fibres also introduce some potential measurement errors. To analyze the effects on performance of using long optical fibres in pulsed TOF rangefinding, a experimental laser rangefinder intended especially for the measurement of to-and-fro ..ion was developed. The rangefinder has a separate optomechanical sensing head, which is connected to the electronic unit by a shielded cable containing the transmitter and receiver fibres. The transmitter has a pulse repetition rate of 1.3 MHz and the receiver includes a high speed transimpedance preamplifier and automatic gain control electronics. An analogue time-to-amplitude converter is employed to obtain high speed, high resolution measurement. The performance of the rangefinder with different fibre lengths is analysed here, concentrating mainly on the resolution and differential non-linearity, the integral non-linearity being of less significance due to the AC nature of the measurement.

1. INTRODUCTION

The time-of-flight (TOF) laser rangefinding technique has recently found many applications in the field of industrial measurements, e.g. the automatic control of robots and manipulators[1,2], 3D-image acquisition[3] and level control measurement[4]. Among the special requirements that are often encountered in practical measurement situations are high speed, high resolution and the ability to measure distances from passive targets as well. Separation of the electronic unit of the measuring device from its optomechanical sensing head is also of great importance in some applications due to environmental hazards, including the presence of explosives, for example. In many cases a time-of-flight laser rangefinder can be employed provided that the optomechanical sensing head is connected to the electronic unit via optical fibres.

o analyze the potential effects on performance of using long optical fibres in pulsed TOF ingefinding, an experimental laser rangefinder for to-and-fro motions was developed, which has a separate fibre optic sensing head at the end of an optical cable such as would enable measurement in demanding industrial environments. This paper describes the performance of the sensor using short (2 m) and long (20 m) fibres, concentrating mainly on the resolution and differential non-linearity, the integral non-linearity being of less significance due to the AC nature of the measurement.

2. CONSTRUCTION OF THE RANGEFINGER

A block diagram of the laser rangefinder is presented in Figure 1. It consists of four functional blocks: the optics, transmitter channel, receiver channel and time interval measurement unit. The sensing head is entirely optomechanical and its size is 16 x 16 x 9 cm. The electronic part of the sensor is located in a standard 19" case.

A block diagram of the transmitter channel is shown in Figure 2. The transmitter electronics generate short current pulses (FWHM about 6 ns, amplitude 1.3 A) for the pigtailed DH laser diode at a constant, crystal controlled repetition rate of 1.3 MHz. The stable pulse repetition rate (PRR) is employed in the time-to-amplitude conversion (TAC). The peak output power of the LD is 500 mW from the fibre.

Short current pulses for the LD are generated using an avalanche transistor driving circuit. The START timing information is obtained directly from the current pulses driving the LD by means of an ECL line driver acting as a comparator and is then quided to the time-to-amplitude converter via a coaxial cable.

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LASER TECHNOLOGIES IN INDUSTRY

6-7-8 June 1988 Porto - PORTUGAL

FIBER-OPTIC INTERFEROMETRIC SENSOR : SIMULTANEOUS MEASUREMENT TEMPERATURE AND PRESSURE

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The use of a fiber-optic Mach-Zehnder interferometer to meassure temperature and pressure is described. The pressure and temperature changes are observed as a motion of an optical interference fringe pattern. Values are calculated for the pressure and temperature from the fringe motion.

Introduction

Pressure and temperature are two connected grandeurs. We present a study to measure simultaneous by Pressure and Temperature in a same environnement. The phase of the light leaving a fiber can be changed by dimensional and index of refraction changes in the fiber. Then, if one fiber is subject to a different strain, pressure (and temperature), temperature (and pressure), than the other, this difference appears as a displacement of the fringes and can be measured by this displacement. This is a basic principle of the fiber-optic strain gauge.

In this paper we present the method and the system for pressure and temperature simultaneous measurement and we present experimental results confirming our approch.

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LASER TECHNOLOGIES IN INDUSTRY

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OPTICAL METROLOGY

LASER DOPPLER

VELOCIMETRY

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Laser-Doppler Anemometry in Hydraulic Research

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ABSTRACT

The paper refers to flow problems on gates already built in Crestuma-Lever power plant. Vibration problems are mentioned and the interest of the knowledge of the way the flow develops on the upper and lower parts of the gates is showed. Laser Doppler measuring technique is generally described and Laser Doppler measurements around gates are presented.

1. INTRODUCTION

Gates are an important part of many hydro-structures. Extensive work has been carried out in the past in order to determine flow discharge rates. Empirical coefficients normally described as a function of water heights at different longitudinal stations enable constructors of gates to design flow obstacles without regarding the complex structure of the generated flow field. Questions in connection with these type of flow are the accuracy f the discharge coefficients stability, effects turbulence characteristics of the resultant flow. To address these questions, flow field information as velocity distribution and recirculating flow regions definition is required. Laser-Doppler anemometry measuring technique characteristics make it extremely useful in this research field.

In section 2 of this paper gate flows are described and practical problems of Crestuma--Lever power plant gates are referred. Laser-Doppler anemometry general principles are presented in section 3 and data concerning measurements in gate flows are available in section 4. In section 5 conclusions and final remarks are given.

2. GATE FLOWS

2.1. Gate flow characteristics

In many fields of Hydraulic Engineering gates are used in order to control discharges and water supplies and/or to regulate the depth of waters in rivers, lakes, water reservoirs, and so on. Hence gates are an important part of many hydraulic structures as for example dams and it is therefore necessary to know the criteria for their design and construction. This requires the forces acting on them to be known. Hydrostatic and hydrodynamic forces have to be taken into account for the design work. A detailed study of literature shows that ample knowledge exists as far as hydrostatic forces are concerned. However knowledge is still lacking in many fields where time dependent flow forces on gates are experienced. Many research efforts are presently under way to get a deeper insight into flow conditions and modern methods of hydromechanics for detailed investigations of gate flow interaction are sed in order to establish general information transferable to hydrostructures.

Coherent oscillations of a flow causing unsteady loading of structures occur in a great variety of situations and most of these oscillations depend on the types of structure and flow involved. Vibration problems of gates have been in practice and in theory studied in prototypes and hydraulic models with the objective of trying to obtain enough information applicable to design criteria. Different vibrating modes of gates have been analysed and reported by Kolkman (1979) concerning mechanisms involving fluctuating discharges. Stability of movable gates concerning their lower edge shapes have been studied (Vrijer 1979) and causes and remedy of vibration of high head gates have been also reported (Saxena, Venkatarama, Ramanathan and Sinnarkar). Earlier studies on gate flows by Naudascher on flow induced forces on fixed gates are worth to be mentioned as well. Flow configurations around gates depend on many parameters but normally a recirculation region resulting from flow separation exists on the gate bottom and high shear can be detected within the flow. The selective amplification characteristic inherent to all shear flows leads to flow fluctuations that are nearly periodic during an initial period of transition for Reynolds numbers near a critical value. At higher Reynolds numbers if an additional control exists, general tendency to turbulence can be overcome and a nearly periodic flow induced excitation may arise.

The shear layer originated by the separation of the flow underneath a gate develops periodic ondulations causing vortices to be shed from the gate at a certain convection speed. These ondulations or vortices, would induce vibration-exciting forces if sustained by a convenient mechanism, which can control the randomly fluctuating flow. The knowledge

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Laser-Doppler measurements of impinging jets

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ABSTRACT

Laser-Doppler measurements of the velocity characteristics of the flowfield resulting from the impingement of single and twin jets against a wall through a low-velocity crossflow are presented and discussed together with visualization of the flow.

The study provides a basis to improve the understanding of the physical mechanisms acting in practically relevant flows such as the flowfield created underneath a vertical take-off aircraft, as well as reliable data to evaluate the numerical solutions of the equations of motion which use turbulence models in order to predict this type of flow.

NOMENCLATURE

D - Diameter of the jet

H - Height of the crossflow channel

k - Turbulence kinetic energy

Re - Reynolds number

S - Distance between the centre of the jets along transversal direction

U - Horizontal velocity, $U = \overline{U} + u'$

V - Vertical velocity, $V = \overline{V} + v'$

X - Horizontal coordinate (positive in the direction of the crossflow, i.e. upstream to downstream)

Y - Vertical coordinate (positive in the direction of the jet flows, i.e. downwards)

Z - Transverse coordinate (zero at central plane; positive in the direction towards the lateral walls)

Subscripts

j - Jet-exit value

o - Crossflow value

1. INTRODUCTION

The flow of multiple impinging jets through a crossflow is typical of many engineering situations and, in particular, of the flowfield beneath a vertical/short take-off and landing, V/STOL, aircraft close to the ground. There, the lift jets interact strongly with the ground plane and with the crossflow, forming a ground vortex that wraps around the impingement regions and an upwash fountain resulting from the collision of the wall jets; these phenomena can lead to engine thrust losses following re-ingestion of the exhaust gases, to oscillations in the pitching and rolling moments and to enhanced entrainment close to the ground. Therefore, the successful development of V/STOL aircraft technology depends upon the knowledge of the physical mechanisms acting in the three-dimensional flow field beneath the aircraft in ground effect.

Detailed measurements of typical single and twin jets against a wall through a low-velocity crossflow are then essential to improve understanding of the structure of the comparatively more complex practical flowfields and to allow the validation of numerical methods used to simulate those practical flows. Towards these objectives, a new set of mean velocity and turbulence data on axisymmetric single and twin impinging jets through a crossflow are presented here.

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A cost-effective LDV system

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ABSTRACT

A low cost laser Doppler velocity measuring system has been developed, and is described in this paper. The principles of period measuring instruments are reviewed and the system parameters important to the measurement are considered. It is shown how the parameters may be adjusted to allow the development of a relatively low-cost instrument which does not have the high performance characteristics of some commercial instruments, but which is more than adequate in performance for most industrial applications.

1. INTRODUCTION

In 1964 it was suggested by Yeh and Cummings[1] that the velocity of a particle could be determined by measuring the frequency shift in light scattered as a particle or object passed through the beam of a laser. It was shown that the measurement of the frequency shift could be achieved by mixing, on the surface of a square law detector, the frequency shifted light with light having no frequency shift. Electronic square law detectors do not respond to optical frequencies, and thus they act as low-pass filters and so produce a difference frequency output proportional to Doppler shift, along with a signal component at zero frequency.

Since this early work there have been many refinements to the technique. A major development occurred in 1970 when Mazunder and Wankum[2] proposed the dual beam system. This has a very specific advantage over other systems since the observed difference in Doppler shifts is independent of the position of the observer, and consequently the setting-up of the system becomes relatively easy.

The measurement of the Doppler shift poses problems. Basically it is achieved by band-pass filtering the output of the square law detector to remove the zero frequency signal component and high frequency noise. This leaves a sinusoidal signal whose frequency is proportional to the velocity of the particle, but which is amplitude modulated and exists for a short time only. In practice the amplitude modulation of the signal is dependent upon the intensity of the light falling upon the particle. With a laser operating in the TEM_{00} mode this is Gaussian, and therefore the sine wave has a Gaussian amplitude modulation. The signal exists only for the time taken for the particle or object to traverse the laser beams.

Techniques which have been used to measure the Doppler shift include spectral analysis[3,4] and frequency tracking[5,6]. Commercial instruments are available using both of these methods, although the application of spectral analysis on a commercial basis is relatively recent and has waited for the development of digital signal processing techniques[7].

The authors have been involved with the development of digital systems for period measurement in laser Doppler systems for many years, and with the application of the instrumentation. They produced one of the first period measuring systems[8]. This has undergone a variety of modifications[9] and in its latest form is available on a single printed circuit board.

The laser Doppler velocimeter has developed mainly for research applications. It has proved useful in carrying out non-contact measurement in situations where conventional instrumentation is not available. However, developments of the application of laser Doppler systems in industry has been at a much slower rate than their development in the research environment. This is due to a variety of factors including the following:

(i) The technique is relatively new, and there is a reluctance by industry to introduce systems regarded as unproven.
(ii) The use of lasers, with associated radiation problems, has been a cause for some concern.
(iii) Measurement systems presently available are expensive.
(iv) There is a considerable amount of "know-how" required when applying laser Doppler systems.

In order to extend the application of the laser Doppler measurement system to more than

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Laser diagnostics of the flow in industrial burners

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ABSTRACT

Laser based visualization of the flow and laser-Doppler measurements of mean and turbulent velocity characteristics are reported in the developing region of the reacting and non-reacting swirling flows of a model of an industrial oxy-fuel burner. The burner consists in a central axysimmetric swirling jet surrounded by sixteen circular jets, simulating the injection of oxygen in practical burners. The experiments have been carried out to investigate the three-dimensional characteristics of the near burner region, the flame structure and the process of flame stabilization and show the efficiency of laser-based diagnostics to study the aerodynamics of industrial burners.

The results suggest that the flame may be represented by laminar flamelet concepts and that the flow becomes axisymmetric upstream of one central-jet diameter. The stabilization of the flame occurs in the vicinity of the quarl, away of the central, swirl-driven recirculation zone. The effect of swirl is, however, essential to improve turbulent mixing and to decrease the entrainment of ambient air into the quarl.

1. INTRODUCTION

The use of laser-based techniques for making measurements in combustion systems has become wide spread. Useful reviews of the lasers available and the various optical methods that have been used to measure velocity and scalar characteristics have been provided, among others, by references 1 to 5. Although many of the new techniques can be used for measurements in development engines and combustion chambers, in practice the techniques have found more use for measurements in laboratory combustors and flames due to difficulties of providing optical access. In general, however, the design of combustion chambers continues to be based on extrapolation of experience gained from their use. Improved design of combustion equipment requires extensive mapping of the flow and scalar fields in order to develop an adequate understanding of the complex coupling that occurs between the fluid mechanics and the chemical reaction, heat transfer and other physical phenomena involved. This paper deals with the application of laser diagnostics to improve knowledge of the aerodynamics of multi-jet swirl burners commonly used in large glass melting kilns.

Multi-jet burner head configurations have been preferred to single-jet geometries in oxy-fuel burner installations, since they improve the mixing efficiency considerably, improving combustion efficiency, e.g. [6], [7]. Their design has, however, relied almost exclusively on empirical methods and a comprehensive study of the operation and basis for the optimization of multi-jet swirl burners has not been published. Further, the properties of swirl-stabilized flames have been shown to be affected by the overall amount of heat released and by the specific location of where heat is released with respect to the recirculating velocity field, e.g. [8]-[10], and, therefore, knowledge of the aerodynamics of the burner flows is essential to optimize their geometry. To achieve these objectives, together with the requirements for highly accurate results in difficult combusting, recirculating environments, laser-based diagnostics are the most suitable techniques to be used.

This work reports laser-based visualization and laser-Doppler measurements of reacting and isothermal, non-reacting, flows for pratically relevant conditions in a laboratory burner, which is a model of the oxy-fuel burner used in the processing glass furnace studied by [11]. The experiments follow those of [12] for non-reacting flows and characterize the three-dimensional behaviour of the near-burner region, the flame structure and the process of flame stabilization for the present configuration.

The following section presents the experimental method and describes in detail the flow configuration and the laser-Doppler velocimeter. Section 3 presents and discusses the results and the last section summarizes the main findings and conclusions.

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Laser Doppler measurement of Fan-belt slippage

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ABSTRACT

An optical system has been developed for measuring the slippage of a flexible fan-belt in an automobile engine. The system is based on the laser Doppler effect and measures the difference in angular velocity of two bodies, rotating at almost the same speed. Using a differential principle, the system output is independent of pulley eccentricity, belt deformations and engine vibrations.

1. INTRODUCTION

To ensure long lifetime of the flexible fan-belt in an automobile engine it is important to avoid slippage between the belt and the pulleys, between which it transfers power. The belt is subject to a time-varying moment from the engine, as well as to strongly time varying load, dependent on the number and nature of devices driven by the belt.

Slippage can be expected to be most likely for four-cylinder engines with variations in power delivered during a cycle, loaded with large one-cylinder hydraulic pumps with very uneven load. The slip, in a given situation, probably depends on the surface finish of the pulley, materials properties of the belt, the mating between belt and pulley as well as of the belt tension. For these reasons, it is of interest to be able to measure slippage on engines in test stands as well as in assembled cars. The interesting range of slip is below 1%, since values above this produces a clearly audible noise.

To be really useful, a system should allow measurements on standard parts with little or no special preparations, and without the need to attach special encoders. These characteristics can be provided by a laser optical method.

2. MEASUREMENT PROBLEM

The measurement of slip in the present situation has a number of characteristic problems, which can be appreciated with the aid of Fig. 1. The belt, which is flat and has a thickness of 6 mm, rests in grooves of a pulley of diameter between *10 and 20 cm*. Since the surface of contact between the belt and the pulley, where the slip occurs, is inaccessible from outside, it is convenient to define the slip as

$$s = (\Omega_2 - \Omega_1)/\Omega_1 \tag{1}$$

where Ω_1 is the angular velocity of the pulley and Ω_2 that of the belt, where it is in contact with the pulley. The first choise of an optical non-contact measurement would be based on measurements *of the velocities of the outer surfaces* of belt and wheel, which are easily accessible from outside. These surface velocities are given by

$$V_{T_1} = R_1 \Omega_1 \tag{2}$$

$$V_{T_2} = (R_1 + \Delta R)\Omega_2$$

where R_1 is the pulley radius and ΔR the protrusion of the belt above the rim of the pulley.

The slip is *basically calculated* as a small difference between the two large quantities Ω_1 and Ω_2, which must be measured with very high accuracy. If we start out from a measurement of the surface velocities V_{T1} and V_{T2}, we must also know the dimensions R_1 and ΔR. For an engine assembled by standard parts, this is simply not possible with the required accuracy. Since the flat belt is flexible, its thickness, and hence ΔR will vary with time, especially during slippage events, where large forces act on the belt. Although it is in principle possible to employ separate sensors to monitor pulley eccentricity and belt thickness and correct the velocities accordingly, adequate accuracy would be very hard to maintain.

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Determination of Pressure changes in fluids by means of Gas Bubbles

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Strengths and limitations of the phase Doppler technique for simultaneous measurements of particle velocity and size

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ABSTRACT

Laser Doppler velocimetry (LDV) is a well-established technique for making non-intrusive measurements of particle velocities in a wide variety of situations. However, the particle velocities so measured are often much more useful if the sizes of the individual particles measured are also known. While it is possible to analyse standard LDV signals to obtain measurements of particle size simultaneously with those of particle velocity in some circumstances, this method is difficult to use on a routine basis. The recent extension of LDV usually known as the *phase-Doppler technique* has, however, made simultaneous size and velocity measurements much more straightforward. The principles of this method and its strengths and limitations will be discussed. In particular, although in principle the method is restricted to cases where the particles or droplets are nearly spherical, evidence will be presented to show that this restriction can be relaxed if the data is processed suitably. It will be shown that as a by-product of this, it is also possible to extract information about the degree of sphericity of the material studied. Finally, application of this technique to a number of industrially important flows will be considered, and some of the problems encountered will be described.

1. INTRODUCTION

Laser Doppler velocimetry (LDV) techniques are well-established for making measurements of velocities of particles and droplets in flow systems. In the simplest instrument, a laser beam is divided to produce two parallel beams, which are then focussed. They cross over at the focal point, and interference fringes are formed in the intersection region, usually known as the probe volume, as shown in the lower part of Figure 1. A particle travelling through this region scatters light from the bright fringes only. When the light is collected and detected, this generates an oscillating signal similar to those shown in Figure 3. The velocity of the particle can be inferred from the frequency of the signal.

There are, however, many circumstances in which it is useful to know not only the overall velocity distribution for the particles, but also how the velocity distribution changes with particle size. This information can only be obtained if particle size can be determined from an instrument which measures individual particle velocities, such as a particle-counting laser *Doppler* velocimeter. It obviously cannot be obtained if a separate instrument such as a Malvern Instruments diffractometer is used for particle sizing.

Size information can be obtained from the simple LDV system described above by using the depth of modulation (visibility) of the signal. This technique has the drawback that it is not easy to use, and it is often the case that the measurements made are not easy to interpret. Alternatively, measurements of the signal amplitude can be used, but in this case careful calibration is required and attenuation of the laser beams and scattered light is a serious problem. If the particles are more or less spherical, however, a much more straightforward method exists. This is the phase-Doppler method, developed independently by Bachalo[1] and by Buchhave[2]. This method will now be discussed.

2. PRINCIPLES OF THE PHASE DOPPLER METHOD

The phase Doppler method relies on using two (or more) detectors at slightly different angles, and comparing the signals from them. In practice, it is convenient to use an arrangement such as that shown in figure 1. A mask with two or three slits is placed close to the collection lens. The light from each slit can be detected separately if a suitable optical arrangement is used, and the signals collected from each slit can be compared.

Now consider what happens when a spherical particle passes through the probe volume. Figure 2 (a) shows the deflection of a single ray when it is incident on the particle at three different points. Both reflection and refraction of the ray are shown. Suppose that the particle is moving upwards so that the three diagrams represent the situation at successive times. It can be seen that the movement of the particle causes the deflected ray to sweep round, as shown in figure 2 (b). Since the ray is swept through a fixed angle as the particle moves through it, irrespective of the particle size, the

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LASER TECHNOLOGIES IN INDUSTRY

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OPTICAL METROLOGY

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LASER for Particle size measurement
Hardware and Software

B. Scarlett

(Manuscript Due)

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The Application of Lasers to Particle Size Measurement.

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Delft University of Technology
The Netherlands.

1. The Scenario

An understanding of the phenomenon of light scattering by small particles has existed for more than one hundred years. The application of that knowledge to particle size measuring instruments has been common for more than fifty years. Many of those early instruments were based on the scattering of white light, often simple extinction measurements. The situation today is one of widespread use of laser measuring techniques in a wide variety of industries. Currently the preponderant use is laboratory based but now is the time that an extension to on-line monitoring and control is possible and will certainly occur. Three technologies which have developed enormously in the past twenty five years have made this possible. Those three developments are the laser, the optic fibre and the computer which have combined to completely revolutionise both the capabilities and the importance of light scattering instruments in industrial applications.

The laser provides a source of light which is versatile, can be intense and is easily focussed and directed. The optic fibre provides a means of directing the light to and from situations which are difficult to access. The computer provides the means to process complex light scattering calculations rapidly, even in real time. These three techniques can now be combined and utilised to make a measurement far faster, more accurate and useful than was ever possible twenty five years ago.

Industries which specified powder products by time consuming sieving or sedimentation techniques now buy laser scattering instruments which produce in a few seconds a beautiful graphic display of the full particle size distribution. Modern industries which seek to protect

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MEASUREMENT OF THE VELOCITY AND SIZE DISTRIBUTION OF DROPLETS AND OF THEIR STATISTICAL CORRELATION

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ABSTRACT

Although the methods used to measure the velocity and size of moving particles are very different and hence make use of separate apparatus, it is often possible to obtain both information simultaneously. The basic equipment requested for this technique is a standard laser doppler anemometer to which two slight modifications are brought: the photomultiplier is set so as to view the measuring volume at right angles and its's pin-hole is replaced by a slit. In these conditions, the electrical output of the photomultiplier can be best interpreted. The statistical correlation between the velocity fluctuation of the particle and that of its diameter is obtained by computing the joint probability de 'ty function of these variables from the probability density of the velocity and the conditional ovability density of the peaks of the envelope.

This method does not require much investment on the optics which is standard; the effort is however transfered to the electronics, data acquisition and digital processing. Although it, is at present less accurate than those base on Fraunhoffer diffraction and gives relative values since it must be calibrated, it has the advantage to yield the velocity and size-velocity correlation. Moreover the electronics can still be improved and the processing speed increased by the use of a fast compiled language.

1. INTRODUCTION

The metrology of fluid dynamics seems to have been one of the most successsful applications of laser technology. This is due to the fact that the exploration of flows by this method is non intrusive as is not the case with traditional instruments such as pitot tubes and hot wire anemometers. The very nature of the laser which concentrate coherent light on a nearly parallel beam, reduces energy losses and makes it possible to use low energy generators. Moreover the analysis of the light scattered by particles (provided that they are spherical) is simpler.

The Laser Doppler Anemometry is probably the first laser technique used for velocity measurements. At its earlier stage, only one component of the mean velocity vector was measured but this was soon ex ded to two components by using a two color laser beam and now to the fluctuating velocities in rbulent flows.

Although it was well known that the light scattered by moving particles contained information concerning their size, it is only later that methods were proposed to extract it from the phototransducer output. These methods fall into two classes: the first is based on the concept of "visibility of fringes" and is only valid for particles with diameters not too different from the value of the interfringe (FARMER [6]), the second one draws the size from the pedestal signal.

The method described here belongs to this last technique. It has been retained because the optical signal is obtained from a standard L.D.A apparatus only slightly modified such as to reduce the influence of the paths of the particles on the phototransducer output. The latter is conditioned in order to to separate information relevant to velocity from that relative to size. The two resulting signals are then processed to yield the various data concerning velocity and size.

BURNAGE

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A Phase Doppler Instrument For Optical Particle Sizing

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ABSTRACT

The features and principles of operation of a phase-Doppler instrument for in-situ optical measurements of size, velocity and concentration are described. Examples of typical measurement results from several different applications are presented.

1. INTRODUCTION

Particle sizing instruments are used in many areas of applied science and engineering. In the fields of, for example, fuel nozzle development, combustion engineering, cavitation research and particle monitoring there is a need for nonintrusive measurements of particle dynamics: size, velocity and concentration distributions. Optical instruments are nonintrusive and provide the capability of accurate measurements with high temporal and spatial resolution.

Instruments for combined size and velocity measurements based on extensions to an LDA (Laser Doppler Anemometer) have been under development for many years. The recent introduction of the PDA (Particle Dynamics Analyzer or Phase Doppler Anemometer) represents a major improvement in the quality and reliability of these instruments. Compared to previous LDA based particle sizing instruments the PDA has a number of advantages: very wide dynamic range from micrometer to millimeter sized particles, high accuracy, in-situ calibration unnecessary and insensitivity to optical disturbances. These characteristics permit measurements to be made in harsh, previously unmanageable environments.

The PDA combines optical, electronic and computer technologies. The present paper describes the operating principles and features of the instrument. Scattering of laser light by spherical particles is described as necessary for understanding the basic principles of operation. Additionally a method of concentration measurement based on automatic characterisation of the instruments measurement cross section is described. The electronic portion of the instrument must measure the frequency and phase of high frequency transient signals, which may have a large noise component when measuring in severe environments. A unique electronic processor based on correlation processing techniques has been developed for this purpose. The operating principles and features of the electronics are described.

Lastly measurement results from several different applications are presented.

2. MEASUREMENT PRINCIPLES

2.1 Laser Doppler Anemometry. The operating principles of an LDA can be easily explained using a simple fringe model. The output from a continuous wave laser is split into two parallel beams which are made to cross at the focus of a spherical lens. A set of plane parallel interference fringes with a spacing determined by the laser wavelength and the angle between the two beams is produced in the crossing region. This is the instruments measurement volume. Small particles in the measurement volume scatter light which is intensity modulated at the rate at which the particles pass the fringe system, i.e. the particles velocity component perpendicular to the plane of the fringes divided by the fringe spacing. The scattered light is collected by a spherical lens (often the same lens as the transmitting lens for a backscatter configuration) and converted into an electrical signal by a high speed photodetector. The frequency of the electrical signal, which is proportional to the particle velocity, is then measured with an electronic device.

This simple fringe model correctly describes the operation of the LDA. In practice attention must be paid to such factors as laser coherence, mode structure and

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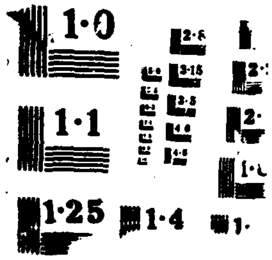
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Particle Size and Velocity Measurement
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K. Bauckhage

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Flocculation/deflocculation studies of kaolin suspensions using LDS

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ABSTRACT

The influence of pH upon kaolin dilute suspensions has been investigated using laser diffraction spectrometry (LDS), the results being compared with a series of sedimentation tests.

Due to its ability to separately explore most different aspects, following the resultant variation of floc size distribution, this technique appears most promising, openning new perspectives for the study of flocculation processes.

1. INTRODUCTION

Flocculation/deflocculation studies of suspended solids have been the subject of many investigations because of their importance in several fields such as soil technology, wastewater treatment, mineral recovery, with ceramics being, perhaps, the best known. The physical properties of such slurries are strongly dependent upon particle size, size distribution, shape, concentration and particle-particle interaction.

The system chosen for this study is an aqueous suspension of a portuguese kaolin, whose beneficiation is intended for industrial purposes.

Kaolinite, a hydrous aluminium silicate, occurs in the form of thin hexagonal platelets (1:1 layer clays). Electrophoresis shows that the suspending particles are negatively charged, mainly as a result of internal crystal imperfections. Since the suspension is neutral, the net negative charge must be compensated by cations which are located on the layer surfaces forming, together with the particle surface, a counter ion atmosphere - the negative double layer.[1] The edge and face double layers are of a different character, the former being a function of the pH of the solution. In fact, in acid conditions the edges assume a positive charge, which causes electrostatic attraction between edges and faces favouring the particles to be brought together, in other words, to flocculate. At high pH values there is a neutralization or charge reversal of the edges, the repulsion becomes significant and the particles deflocculate.

The behaviour of flocculated suspensions has been successfully explained in terms of particle interaction forces and the correspondent association modes.[2,3] Rheological and sedimentation techniques revealed that at low pH edge-face association occurs, leading to an open structure ("card house") of high apparent viscosity and voluminous sediment. Elevation of pH gradually weakens the particle interaction with a consequent reduction in viscosity and, eventually, conducting to a compact sediment.

It has also been advanced[4] that in a flocculated suspension, the basic flow units are not the primary particles but clusters of particles, called flocs, which can combine to form aggregates, whose configuration is a function of the local shear field intensity.

In this work a new technique, laser diffraction spectrometry, currently used for particle size analysis, is proposed to study the flocculation process, being fundamentally different from the classical method of sedimentation. Here, the measurements are undertaken in agitated conditions enabling, it is believed, the results to be more directly related with those of rheology. It should be emphasized that unagitated suspensions, apparently stable, are actually far from their equilibrium state.[5]

However, in order to interpret the results obtained with the above technique, and also to compare the results for this kaolin with those refered to in literature, obtained via sedimentation, it was decided to carry out a number of sedimentation tests, measuring only the final sediment volumes.

2. PRINCIPLES OF MEASUREMENT

Laser diffraction spectrometry (LDS) is a non-intrusive, simple and fast technique, used commonly, nowadays, to characterize particles dispersed either in liquids or gas, and whose operating principles are as follows. A low power He/Ne laser produces a parallel monochromatic beam of light which illuminates the particles crossing the laser beam through an appropriate sample cell. The light scattered by the particles in the forward direction is measured at various angles to give a stationary pattern, which is focussed, by a

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Effect of shape, structure and texture on the accuracy of size characterization of fineparticles by light scattering

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ABSTRACT

Deconvolution of the complex diffraction patterns generated by laser inspection of a random array of fineparticles is a widely used method for characterizing the size distribution of the scattering fineparticles. Interpretive hypothesis used to deconvolute the diffraction pattern use simplified assumptions which usually ignore the diffracting effect of structural features of the fineparticle profiles. For quality control and processing research this is not a serious limitation of the methodology. However if one tries to use these methods to evaluate the size and concentration of respirable dust one must adjust the data processing involved in the deconvolution to take into account various structured features of the dust. In this communication the effect of sharp edges and fractal structure in respirable dust such as quartz, diesel exhausts, flyash and nuclear melt down fumes on the group diffraction pattern of a random array are discussed.

1. INTRODUCTION

The pioneers involved in the development of instruments for characterizing the shape and size of fineparticles knew that the information they needed was present in the group diffraction pattern of a random array of fineparticles to be characterized. However, before the development of relatively inexpensive electro-optic interfaces, and computerized data processing procedures, the fact that the information was present in the diffraction pattern remained an academic novelty except for fineparticle systems with a small range of sizes. Thus, over a 100 years ago Young the developer of light diffraction theory used diffraction patterns to measure the fineness of Australian wool. He described his instrument as an eriometer from the Greek word for "wool". Heywood in 1947 described the use of a similar device for measuring the size of blood cells. The invention of the laser with concurrent developments in electro-optic interfaces and low cost computer power led to the development in the late 1970's of several commercial instruments for sizing fineparticles based upon the deconvolution of the group of diffraction pattern[1,2,3,4]. Many of the significant features of these commercial instruments had been anticipated a decade earlier by J.H. Talbot who attempted to deconvolute the diffraction pattern using relatively insensitive electronic filtering circuits[5]. The commercial importance of many of the diffractometers for characterizing fineparticles led to secrecy with respect to the deconvolution algorithms used in various instruments. As a consequence, it has been difficult for the scientific community to evaluate the fundamental accuracy of the various commercial instruments[6,7]. As a consequence, the performance of many of the commercial diffractometers has been explored empirically by direct measurement of distribution functions by different characterization procedures[8]. The precision of the commercially available diffractometers is very high but the accuracy is often unknown. Diffractometers have proved useful in studies where the main interest of the technologist is in changes occurring within a fineparticle population being produced on a commercial basis. Thus, if one is producing a powdered chemical on a routine basis, the size distribution of a desirable product as compared to one which indicates that the process needs to be adjusted can readily be ascertained. In general, the deconvolution algorithm interpret the diffraction pattern in terms of spheres of equivalent scattering size. It is assumed that one only needs to concern oneself with the central maximum of the diffraction pattern since it contains most of the energy of the diffraction pattern. This type of assumption is not unreasonable for many industrial products but can lead to serious problems if the object being studied does not have a simple structure and/or contains sharp edges in its structure. In our research studies we have a general interest in characterizing a range of powdered products ranging from those produced by any pulverization process to a study of those produced by precipitation and/or fuming of the fineparticles. We also have a specific interest in the possibility of monitoring the levels of hazardous dust in the working environment by means of light scattering devices. Thus, if one can adequately measure the dust levels in a working area by means of the attenuation of a light beam one has a relatively simple and low cost monitor for evaluating the dust in the area. In this communication, we present some preliminary data on the effect of edges and open structure on the diffraction patterns of fineparticles. The physical importance of this preliminary data is explored briefly.

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Using Fast-Fourier-Transform (FFT) for the

Phase-Doppler-Difference-Analysis of Powder Metal Sprays

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Abstract

Application of the phase-Doppler-difference-analysis to spraying and compacting molten metals to measure particle size and velocity distributions is difficult because of the high background noise level of the signals detected by the photodetectors. Common counter processors will not work properly with such noisy signals. Therefore a modified laser-Doppler-processor based on the fast Fourier transform is described and its performance evaluated by simulation and by analysing signals originating from rough and nonspherical CuAl particles.

Introduction

A modified laser-Doppler-anemometer (LDVS) for simultaneous size and velocity measurements of individual spherical particles measures the velocity in the most familiar manner by detecting the frequency of the Doppler shift of the light scattered from a moving particle. The diameter of this particle is determined by detecting the phase difference between the two Doppler bursts received from two photodetectors situated at different angular positions parallel to the interesting velocity component of the particle. The overall set-up of the dual beam system used is shown schematically in Fig. 1. It is the most common arrangement of a LDVS. The measuring volume is formed by the two interfering laser beams. It is an ellipsoid and may be interpreted by the fringe model also shown in Fig. 1. The edges of the ellipsoid are defined as the contour where the amplitude of the interference field is e^{-2} of the maximum value. The signals detected by the photodetectors are generated by reflected or refracted fringes from a particle crossing the measuring volume. Accordingly the signals recieved from the two photodetectors have a frequency that varies with particle velocity. Counters are the most common systems for processing the photodetector signals. At high signal-to-noise ratios (SNR) above approximately 8dB they have prove reliable [1]. Signal validation schemes are used to discard bursts of poorer quality. At low signal-to-noise ratios spectral analysis provides better estimates of the velocity than counters [2].

Noise is especially a problem in using LDVS for the analysis or process control of spray compacting processes. Noise may result from very small or rough particles, reduced laser power, poor light detectors, background illumination, limited signal quantization or misaligned optics. Different processors have been described using spectral analysis to estimate velocities of particles. Lading [3] introduces a burst spectrum analyser based on a hard wired fast Fourier transform (FFT) processor. Veynante and Candel [4] tested a nonlinear spectral analysis approach. Neither processor schemes yields phase difference information. In this paper a spectral analysis processor providing phase difference and frequency information from the photodetector signals is described and its performance is evaluated with respect to the severe conditions of spraying and compacting molten metals.

Processing algorithm

The spectral analysis processor is based on the fast Fourier transform (FFT) followed by an interpolation algorithm. Interpolation is essential because frequency resolution of the FFT is limited by the short duration of the bursts and the number of sampling points per burst. High computational speed requires a low number of sampling points. Different interpolation schemes have been published, e.g. least-mean-squares parabolic fit to the five FFT points nearest to the maximum [5], phase interpolation [6] and interpolation using all spectral components [7].

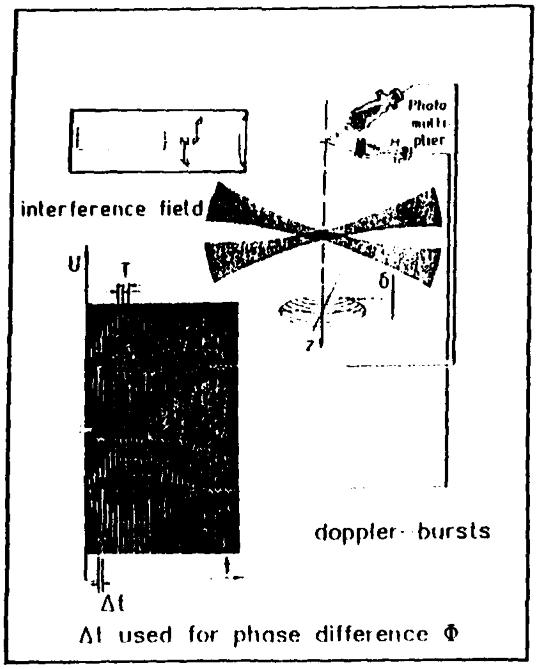

Figure 1. Schematic of the LDVS-method.

On-line Measurement of Crystal Size and Shape
Using Combined Optical Techniques

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(Manuscript Due)

On-line measurement of crystal size and shape using combined optical techniques

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ABSTRACT

A forward laser light scattering technique is used for on-line control of a continuous crystallizer. The recorded scattering pattern is processed and translated into a crystal size distribution. Reliable data are a prerequisite for process control. Hence much attention is paid to both recording and data processing. Due to a number of specific features encountered, e.g. high particle concentration, wide size range, several modifications had to be made.

1. LASER DIFFRACTION AS A TECHNIQUE FOR PROCESS CONTROL

A number of instruments based on the principles of laser diffraction to measure particle size distributions have been developed in the last decade. Starting off as a standard laboratory technique, these instruments have more and more proven to be very successful as well in on-line configurations for process and product control. This is mainly due to the advantages offered by this technique, e.g. speed, no destruction of the particles examined and reproducibility.
In most cases however, a number of specific problems have to be overcome first. An example where laser diffraction is used to control a continuous crystallizer will be elucidated in section 3 [1].

2. INTRODUCTION TO THE PRINCIPLES OF LASER DIFFRACTION

In instruments based on the laser diffraction technique, light from a laser (2 mW, He/Ne λ = 632.8 nm) is first expanded before illuminating the particle field. The particles present will either absorp or scatter the incident light according to their size, shape and refractive index. The scattered light is subsequently collimated by a Fourier transform lens and focussed onto a photo diode detector. In this way a composite scattering pattern developed from all contributing particles is recorded as a function of the scattered angle. Finally, the received scattering pattern is deconvoluted into a particle size distribution.
The particles to be measured using this technique are typically in the range of 1 to 2000 microns.
A schematic view of a laser diffraction instrument is presented in figure 1.

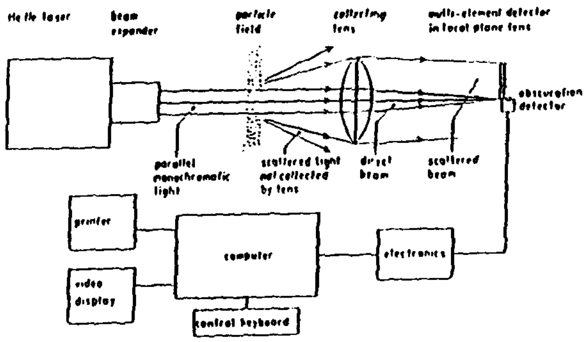

Figure 1. The basics of a laser diffraction instrument.

3. ADAPTED AND MODIFIED CONFIGURATION

At Delft University of Technology the UNIAK [2] project is concerned with the development of new control strategies for an industrial continuous crystallizer. The crystallizer is of the evaporative Draft Tube Baffled (DTB) type and is operational on a pilot plant scale (V = 1000 l). Ammonium sulphate, which is cube shaped and highly transparent is chosen to be the crystallizing material. Besides the more conventional input as e.g. temperature, pressure and flow rates, the new control scheme is based on actual information of the crystal size distribution (CSD) in the three main streams, being the fines, product and feed stream. The subsequent shifts observed in the crystal size distributions are then used to adjust the process parameters according to the control scheme applied. This information is obtained using an on-line configuration of an instrument based on laser diffraction (Malvern 2600C Particle Sizer). However, due to the following list of specific problems encountered a number of modifications in both the measuring and the data processing strategy had to be made:

1. More than one process stream needs to be monitored.
2. A very high concentration of crystals is met in the product stream (30% Wt).
3. The ammonium sulphate crystals are highly transparent and non-spherical.
4. The complete crystal size range going from the fines to the product stream is too wide to be measured at one magnification.

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BUILDING A PARTICLE SIZE ANALYZER

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ABSTRACT

This contribution describes the design of a particle size analyzer based on the diffraction of the light of a small He-Ne Laser. The emerging radiation is received on a set of photodetectors and fed into a personal microcomputer.

1. Principle of the method

The basis of this particle analyzer (Figure 1) is the diffraction of the light of a small He-Ne Laser (2 mW). The beam is expanded, filtered and collimated to approximately 50 milimeters (Figure 2).

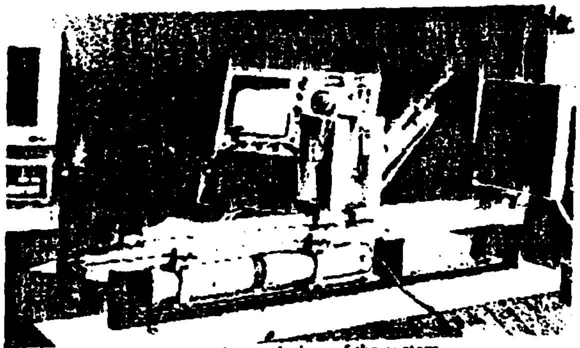

Figure 1- General view of the system

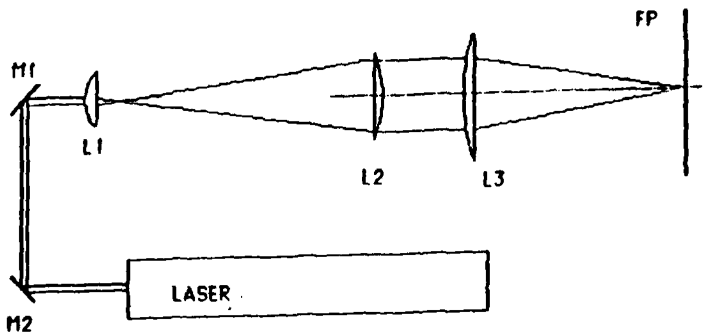

Figure 2 Mounting arrangement

Placing in the beam a cell of transparent plane and parallel windows, filled with the transparent liquid with the particles in study in suspension and in constant motion (the liquid is flowing through the cell) the diffraction pattern is obtained.

[illegible]

Laser for Industrial Materials Processing

A. Sona

(Manuscript Due)

LASER TECHNOLOGIES IN INDUSTRY

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APPLICATIONS TO ROBOTICS AND AUTOMATION

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Some Viewpoints on Laser Automation and Processing Quality Control

by
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ABSTRACT.

Since 1970 high powered lasers have been used in industry for cutting, welding and surface treatment. These operations are normally automated by some form of pre-programmed operation. None of the existing industrial systems incorporates process quality feedback control. The operating routines are all prefixed regardless of possible undesired changes requiring resetting of those conditions during operation. As a result the quality of products can not be guaranteed except by past experience. This problem has become increasingly apparent to industry and research scientists, particularly now that it may be soluble. Many attempts have been made to find a solution; so far they have served to show that the task is complex.

This paper reviews previous achievements in laser automation and process feedback control. It discusses some of the techniques which might be employed for future developments.

1. INTRODUCTION:

Not only is the laser a new source of industrial energy but automation has also advanced into new regions of sophistication. Open loop control has been with us since the industrial revolution, likewise some forms of closed loop control based on simple mechanical devices such as a speed governor on an engine. However the implications of closed loop control have expanded beyond the imagination of our fathers with the advent of the computer at prices which can be afforded for dedicated machinery. Larger computer memories and higher computer speeds have only recently opened up the possibility of a closed loop on the processing logic which leads to a form of artificial intelligence - or a machine which learns from experience. The laser opens up unique possibilities in automation. This is due to the 'noise' free nature of processing with optical power. The energy delivery system has no associated electric, magnetic, thermal or sonic fields other than those generated by the process itself. Thus the first step in automation, that of in-process sensing, is greatly simplified. The optical power from the laser can be rapidly switched, controlled or redirected fulfilling the second step required in automation. Thus it has been argued that the laser is an ideal partner for the robot.

This article looks at progress which has been made in laser automation and process quality control from the point of view of how it was then, is now and possibly will be tomorrow.

2. THEN -- AUTOMATED OPEN LOOP LASER PROCESSING SYSTEMS.
(Integration of the laser with a work table or robot) (1,2,3).

2.1. Automatic Operation - Speed and Position Control.

The first application of automation to laser processing was the automatic movement of the beam relative to the workpiece. This form of automation is essential for successful operation due to the precise nature and high speeds involved in laser processing - such as cutting, welding or surface treatment.

2.1.1. Automatic Movement.

The choice was to move the beam, the workpiece or both. Numerous designs have been suggested as shown in fig 1. The design points which have been found to be important are:

a) Positioning Accuracy:

The focussed laser beam is only around 0.1mm diameter, any deviation of this magnitude is likely to be visible on a cut edge or mean that a weld seam is not accurately followed. It has been suggested by Tight (1) that the market for laser robots is critically dependent on accuracy as shown in fig 2.

Robot Guided Laser for 3-Dimensional Processing

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(Manuscript Due)

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Seam Following for Automated Welding

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ABSTRACT

The use of laser light and vision systems for the identification of seams to be welded is discussed. Systems are described which are compact and allow access to remote locations by using coherent fibre optic bundles. Present computing speeds allow simple structures to be identified within the time (<20ms) required to capture a frame.

Future developments are discussed and are limited to the enhancement of the computing power especially by use of the transputer. This will allow very complex structures to be analysed as well as real time adaptive control to be introduced for the faster welding processes. The role of expert systems will become important to check and maintain weld quality.

1. INTRODUCTION

The low cost automation[1] of the welding process has been undertaken since the availability of the microprocessor in the late 70's. The project is a long term activity because the welder is a very highly skilled and intelligent operator who is difficult to replace by microcomputer based techniques. The automation programme was initially aimed at gas welding processes such as TIG (Tungsten Inert Gas), MIG (Metal Inert Gas) and Sub arc (Submerged arc) but has more recently been applied to laser and electron beam welding. The research was initially based upon the 8 bit microprocessors (e.g. INTEL 8080) (see Figure 1) and thus only allowed the control of the welding current and the manipulator position for straight line welds. As more advanced 16 bit microprocessors became available more complex tasks could be undertaken. The use of currently available devices such as INTEL (80286/386) and the Transputer (T800-20) now permit a fully automated welding cell to be researched[2].

After the welding current and torch manipulation were accurately controlled, problems related to the correct placement of welding beads and their quality were undertaken. Advanced systems have been well researched primarily for the TIG and MIG welding processes. The more recent application of high power CO_2 lasers to the welding of thick structures has requested that the developed technology should now be applied to this problem. The plasmas produced by the TIG/MIG and the laser welding processes are similar. The main difference is that the laser welding is done at faster speeds which are approximately ten times the welding speed of the fastest TIG (hot wire) process, which has a torch speed of 10 mm/sec. In this paper, are described the techniques available for seam following and bead examination and emphasis is given to those methods capable of being applied to CO_2 laser welding.

2. SEAM FOLLOWERS

The rapid developments of miniature lasers, CCD cameras and microcomputers has encouraged the development of vision based sensors to the extent that they are now the dominant sensor.

A review[1] of mechanically based seam followers has been given by Lenn. Recent developments which mechanically sweep either infra red radiation or acoustic beams over the seam in order to find its central position have been described[3] by Tan and Lucas. These sensors are useful as low cost, off line seam following devices because the robot's speed may be reduced to allow accurate identification of the seam to be ascertained. Because mechanically based seam followers need a fraction of a second to identify the seam position, this usually rules out on line welding especially in the faster TIG and MIG welding processes and most definitely in CO_2 laser welding systems. The requirements of a vision based system are shown in Figure 2.

2.1 Light Sources

The laser light source may be either a solid state laser (wavelength 780nm, 0.5 - 30 mW) or a Helium Neon gas laser (wavelength 633 nm, 0.5 - 30 mW). The solid state laser is both low cost and very compact, its retaining can being only a few mms in diameter. It is disadvantaged by the fact that its wavelength is just outside the visible region. The He Ne laser is more expensive and bulky but the laser light may be transported along a single 50 μm fibre optic cable having miniature "Selfoc" graded glass lens fused to its ends. The purpose of these lenses is to both generate a 1mm parallel light beam from the end of the fibre and to allow the laser light to be efficiently put into the fibre as shown in Figure 3. Since both lasers produce beams approximately 1mm in diameter simple cylindrical optical systems may be used to produce strip illumination of the seams as illustrated in Figure 4.

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Development of a stabilized CO_2 laser

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ABSTRACT

A cw CO_2 laser capable of tuning through a number of rotational lines using the laser signature technique has been developed. The optogalvanic effect is used in a control loop for active stabilization. Frequency fluctuation in the long term is better than 3 parts in 10^7. The laser has an output power of 6 W on the 10P(20) line.

1. INTRODUCTION

The large number of CO_2 laser transitions (9 and 10 μm bands) makes this laser suitable for many applications: Plasma diagnostics[1], Remote sensing[2] and Multiwavelength interferometry[3], for example.

In lasers that use a diffraction grating as an intracavity dispersive element one can achieve full flexibility in those applications. However, in some occasions only a few lines are needed. In those cases line selection can be made by simply varying the cavity length.

We report the development of a CO_2 laser employing the changes in discharge impedance with intracavity power in a feedback loop to lock the laser to line center. Tuning is achieved by controling the cavity length by means of a piezoelectric translator.

2. THE OPTO-GALVANIC (VOLTAIC) EFFECT

The opto-galvanic effect (OGE) can be described as a change of the impedance of a gas discharge due to absorption or emission of radiation. The effect is usually observed by measuring the variation of the current (opto-galvanic) or voltage (opto-voltaic).

The CO_2 laser is highly efficient. Thus, any change in the radiation field can influence several discharge macroscopy parameters such as pressure, gas temperature or discharge impedance to a significant extent.

These effects have been thoroughly studied[4,5], and subsequently applied in stabilization schemes[6,7].

In the CO_2 laser, the energy of the upper level can be lost by means of stimulated emission or by collision processes.

If the cavity is misaligned (no loss of energy by stimulated emission) the translational energy of the gas will increase due to relaxation of the upper level leading to an increase in temperature and consequently in the gas density number. Therefore there w . be an impedance increase that could be observed as an increase in the voltage applied to the laser (in constant current mode).

3. EXPERIMENTAL SET-UP

3.1 Laser design

Fig. 1 Shows the block diagram of our experimental set-up: The laser tube consist of a 60 cm long pyrex discharge tube with 7 mm inner diameter surrounded by a water jacket. A slow flow mode of operation, as opposed to sealed-off operation, was chosen because of ease of fabrication.

A four rod INVAR structure (25 mm diameter) is used to support the mirror assemblies. Mirror alignment is made with micrometers.

The optical resonator consist of a plane 85% ZnSe partial reflector (M1) and a 20 m radius total reflector mirror (M2) mounted on a commercial piezo-electric translator (PZT). Mirror separation is 115 cm.

The discharge was maintained between two stainless steel electrodes which are the supports for the ZnSe Brewster windows. Apparently no damage to the windows (Sputtering, deposits) was noticed. The power supply was a 30 kV, 30 mA commercial unit and could be

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+P6

Beam delivery system for a CO_2 laser

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ABSTRACT

In order to integrate a low power (70 W) CO_2 laser into a materials processing system, a device has been developed which enables the beam emerging the laser to be guided down to the workpiece, on which it is focused. The resulting system in[illegible]les a mirror which is located in such a way as to deflect the beam by 90°; a means is provided for its fine adjusting in [illegible]o mutually perpendicular directions. The vertical tube was designed in order to allow the alternative fitting of lenses with the most usual focal lengths in the intended range of applications. The terminal nozzle was shaped taking into account the need for either a cutting gas shroud or a means for drawing away the smoke developed during cutting.

1. INTRODUCTION

An ever growing range of applications of laser technology is penetrating today the various domains of human activity: material processing, medicine, biology, telecommunications, metrology, etc..

The present paper describes a development which can be included in the area of materials processing. A CO_2 laser[1] was integrated in a system for cutting (contouring) and engraving (marking) of materials. One point to be considered in that kind of applications concerns the way the coupling of the beam between the laser and the workpiece is accomplished. The following topologies may be found currently in this kind of laser machines:

- fixed optics, movable workpiece
- movable optics, fixed workpiece
- mixed system.

In our laser cutting/engraving machine[2] the first of these concepts was chosen; the machine includes a stepper motor d[illegible]n X-Y table, which supports the workpiece; table movement is controlled by a CNC. In this configuration, the laser beam has to be properly guided from the laser down to the workpiece. A prototype beam delivery system was developed for [illegible]is purpose and is described hereafter.

2. DESCRIPTION

The figure on the next page shows schematically the device that was designed.

On the upper part, provision has been made to fit a beam deflecting mirror. NiCu mirrors with a 1.5" diameter have been adopted. On the back face of such a mirror a threaded bore is usually provided. This is used to screw in it a threaded bolt whose other end passes through a small rotula which fits in a corresponding cavity machined in an aluminium disc. This disc rests on the 45° surface (relative to the beam) of the main body of the mirror support.

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LASER CUTTING

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~~The~~ laser cutting ~~technology~~

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ABSTRACT

In this paper the *laser cutting technology* is shortly described. The history of the modern laser cutting technology is reviewed. The laser cutting process and its most important parameters are described *briefly*. *Finally the trends* in the technology is discussed briefly.

1. INTRODUCTION

The laser cutting technology is today the most widespread high power laser processing application, and *more* than thousand units *of* typical systems consisting of a 500-1.000 watt CO_2-laser combined with a two-dimensional CNC-controlled cutting table are performing high quality, precise short *series of* sheet metal cutting, mainly in mild steel, but also in other materials as for example stainless steel and aluminium.

The sheet metal laser cutting process is a thermal cutting process resulting in higher quality *and precision than any other* thermal cutting process. Therefore, the laser, although it is an expensive thermal heat source, is the common choise, when thermal cutting tools are applied to *large, high precision* CNC-controlled sheet metal shaping systems.

The development *of the laser* cutting process of today began with the development of the high power lasers. The major laser for cutting, the CO_2-laser, was developed in principle in 1963.[1,2] Through *the following* decade, the CO_2-laser was developed from the initial milliwatt output level to multikilowatt output range. Allready a few years after the first CO_2-laser was reported *operating*, lasers with an output power of a sufficient level for sheet metal cutting was developed.

Investigations in application of this CW laser source were initiated, and in 1967 the *application of a coaxially* gas jet for laser cutting was reported.[3,4] In the following 10 years, industrial CO_2-lasers were used mainly for cutting non-metallic *materials, but still the industrial* use of lasers for metal cutting was quite limited.

In 1979 the effect of the laser light polarization was discovered,[5,6] and the last technical obstracle to the industrial application of lasers for metal cutting was removed. In *less than one* year after the discovery of this major parameter in laser cutting, reflective phase-shift mirror coatings for high power CO_2-laser beams were available and soon the numbers of industrial sheet metal cutting systems available as well as the sales of these systems increased rapidly. The sheet metal cutting process *was an* established industrial production technology and the laser cutting application suddenly became the most important market for the high power laser manufacturers.

The laser cutting technology is however *more than laser cutting*. Industrial application of this cutting tool requires a system consisting of:

- laser source
- NC-controlled positioning system
- laser beam path
- cutting "tool" (lens/nozzle system)
- process gas supply

In addition to this production system, an efficient off-line programming facility is important to utilize the flexibility of the numeric controlled cutting system and finally the material flow around the cutting system is of importance.

To utilize the quality, precision and cutting rates, obtainable with a laser, strong demands on the speed and resolution of the NC-system and on the acceleration, speed and rigidity of the positioning system must be satisfied. It is clear, that the development *of the* laser cutting technology therefore not only was depending on the development of the laser source and the processing tecnique, but also on the development of the computer technology.

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Thermical modelisation of laser cutting process

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ABSTRACT

This paper presents a method of thermical modelisation of laser cutting in the monodimensional case, using the finit differences method : this model has the simplicity convenience and can resolve the problem of the cutting front mobility.

1. INTRODUCTION

The experimental results shows that the morphology of the cutted surface is different versus the depth, and that the profile height distributions present a random character more prominent in bottom zone than in upper one [1,2,3]. The optimization of machining parameters is not always favourable to obtain a good cutting quality especially in the case of a thick workpiece. The thermic approach of the cutting process takes a particular interest, thanks to the theoretical support it can induce. The major works about thermical modelisation have been done in the case of the material surface treatment. The laser cutting is treated only with the maximal cutting speed by some global methods of energy balance [9,10]. The main problem for the thermical modelisation of laser cutting process is the cutting front mobility.

This paper presents a method of thermical modelisation in the mono-dimensional case : this model has the simplicity convenience ; nevertheless, its numerical results are enough satisfactory.

With this modelisation, we can study essentially the cutting start and the temperature distribution along the direction of cutting front motion ; we can also study the influence of oxydation reaction in the upper zone.

This study allows us to understand some phenomena produced on the front during the cutting process, together with the results of simultaneous observation of the cutting process[6].

2. HYPOTHESIS

2.1. Simplification

First, to simplify the tri-dimensional problem to a bi-dimensional one, we consider only a narrow band parallel to the laser beam moving direction, and on the central line of the laser beam motion (Fig.1). Moreover, we consider that the workpiece is very thin, and we suppose that the thermical energies and the temperatures are homogeneous versus the depth. Finally, we obtain a mono-dimensional model. In the meantime, we could not forget that in the real case (a tridimensional one), there are some thermical flows along the directions of piece width and depth. Nevertheless, we could approach this process using this model, because the distributions of thermical energy and of temperature are, generally, symmetrical with respect to the laser beam moving axis, and are more homogeneous along the depth, provided that the workpiece is thin.

2.2. Hypothesis

To make the numerical calculations easier, using this model, we generally suppose that :

H1 The temperatures are uniform through the width of the considered slice (OX axis). So, there is no thermical flow in this direction ;

H2 All the physico-chimical properties of the material are independant of its temperature, and the absorption coefficient of light is constant ;

H3 The workpiece thickness is relatively small, and all the distributions (energy and temperature, etc.) are uniform through the depth (OZ axis) ;

H4 The melted materials are immediately ejected to outside, with a speed near to the gas flow one, which is very high ;

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Heat conduction and mass transfer in laser cutting

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ABSTRACT

1 INTRODUCTION

The most important phenomena contributing to laser cutting are heating of the workpiece by absorbed laser radiation and exothermic reaction, heat loss due to thermal conduction and evaporation and melting of the workpiece in the vicinity of the focus of the laser beam. Material removal takes place since liquid material is blown away by the oxygen flow and due to evaporation. To obtain a deeper insight into these main phenomena of laser cutting, and to understand their relative importance, heating of the workpiece and material removal will be closely regarded and analyzed.

The first part of the paper is devoted to the absorption of laser radiation and their dependence on the different parameters of the cutting process, as wavelength, polarization and angle of incidence of the laser beam employed for cutting.

In the second part the energy gain due to exothermic reaction between oxygen and the material of the workpiece is discussed for the most important case, cutting of steel.

The third part of the paper deals with the analysis of the temperature distribution obtained in the workpiece under consideration of heat gain as treated in part one and two under consideration of heat conduction and virtual cooling due to the movement of the laser beam over the surface of the workpiece.

Finally, the last chapter deals with material removal by melting and evaporation and the resulting cutting speed and their dependence on the process paramters.

2. ABSORPTION OF RADIATION BY THE WORKPIECE

The incident laser beam reaches the surface of the workpiece and penetrates into the cut kerf and propagates then usually freely into the bulk of the material (Fig.1). At each depth a certain portion of the beam cross section hits a part of the nearly vertical, but slightly inclined momentary end of the kerf - the erosion front - and is absorbed due to the Fresnel mechanism /1/. The degree of absorption depends in that case strongly on the polarization direction and on the angle of incidence. In the case of polarization parallel to the cut, the reflection depends strongly on the angle of incidence and a maximum of nearly 90% is absorbed for an angle of incidence of 85 degrees, that means for nearly striping incidence. Obviously the latter case of polarization is favourable for laser cutting, since then relatively high absorption is obtained due to the fact, that the erosion front is nearly vertical.

In reactive gas-assisted laser cutting, the surface of the molten layer, that usually covers the momentary end of the kerf, is hit by a dense stream of oxygen. Due to the bombardment with oxygen, oxidized metal is produced at the surface of the molten layer and the liquid layer is covered with a thin oxide film. Since the reflectivity of oxides at λ = 10.6 μm is much lower than that of pure metals due to the lower conductivity of oxides, the presence of oxide as mentioned above raises the 10% absorption of pure steel (90 degree angle of incidence) to a maximum of 60%. Considering the latter arguments an absorption of 80% of the incident radiation seems to be most appropriate /2/.

Current Report on CO_2 Laser Applications in Japan

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ABSTRACT

Since high-precision cutting has been achieved by laser, this has widened the field of applications of laser cutting, largely contributing to making the laser technology popular. This report describes the pulse characteristics and beam quality which have contributed to achieving the high precision cutting, by showing the relationship between them and cutting accuracy. The laser cutting applications in Japan are also introduced.

KEYWORDS

Laser beam, Accuracy, High-peak pulse, Thermally affected layer, Surface roughness

1. INTRODUCTION

The laser beam which can condense rays at a high energy density is used for various processing as the excellent heat source which instantaneously melts, vaporizes and eliminates material. Fig. 1 shows the trend of the numbers of CO_2 laser processing machines delivered in Japan.[1] It is expected that the number will reach approx. 670 in 1987 (12% more than that of the previous year). The total number of machines in operation will reach 2000 to 2500. Metallic material cutting is the most popular among various applications, accounting for approx. 80%.

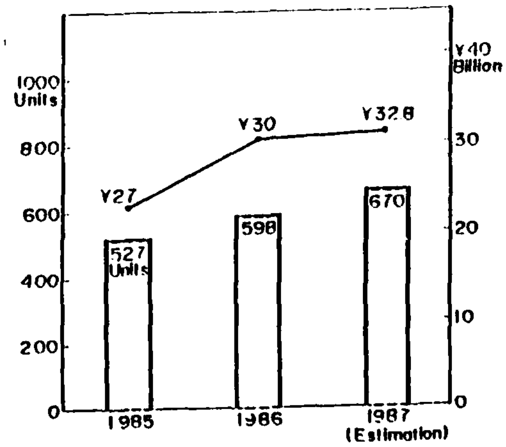

Fig.1 Progress of market scale of CO2 laser processing machines

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CO_2 Laser Cutting of Titanium Alloys

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Abstract

An in-depth experimental investigation has been carried out into the cutting characteristics of titanium alloys which has led to the development of new techniques. Problems usually associated with CO_2 laser cutting of Ti alloys (i.e. dross and O_2, N_2, contamination) have been eliminated by the use of auxiliary argon jets employed during cutting. Cuts generated by this multiple inert gas jet technique have been analysed using profilometry and surface chemical analysis. Oxygen and nitrogen contamination levels were found to be lower than for mechanically guillotined edges. Surface roughness values were of the same order of magnitude as milled samples.

Introduction

Accurate profiling of titanium alloy sheet is difficult to achieve by traditional cutting methods. Profiling techniques fall roughly into two categories; thermal and mechanical, each of which have drawbacks when titanium alloys are considered. Thermal methods of cutting tend to produce a chemically contaminated edge due to atmospheric oxygen and nitrogen absorption at high temperatures. Oxygen and nitrogen absorption of this sort severely embrittles the cut edge and thus drastically reduces the fatigue life of the material, an important consideration in many titanium alloy applications. A more minor problem is the generation of a heat affected zone (HAZ) in the area bordering the cut edge. Mechanical methods of cutting these tough alloys experience problems which not only slow the process but can give rise to cut zone overheating and thus the same deleterious symptoms as thermal cutting.

Although laser cutting is a thermal technique the heat input to the sheet is minimal as a result of the narrow cut zone established (0.1 - 0.4mm diameter).

The focused laser beam acts as a tranquil heat source on the surface of the material (see Fig. 1) and it is therefore a simple matter to shroud the cut zone in an inert gas. This gas acts coaxially with the laser beam on the cut zone and is also responsible for the shearing of the molten pool to generate a cut.

In spite of these advantages (minimum thermal input to substrate and inert gas shielding) over other thermal cutting methods, laser cutting by the simple technique shown schematically in Figure 1 suffers from two drawbacks:

1. Although the laser generated molten pool is sheared by the inert gas jet, a proportion of this melt is left adhering to the underside of the cut in the form of resolidified droplets (or dross). These droplets can be clearly seen in Figure 2, a set of electron micrographs of typical cut edges. This dross needs subsequent removal by mechanical methods (eg - grinding).

2. The accumulation of dross on the lower edge of the cut also gives rise to chemical contamination of the cut edge. The droplets, as they solidify behind the cut zone, form a type of thermal reservoir keeping the recently cut zone at elevated temperatures after the passage of the laser and its coaxial inert gas jet. This hot zone is then easily contaminated by atmospheric gasses particularly oxygen.

It is clear therefore that a typical laser cut titanium alloy edge produced by the simple laser-inert gas combination (Fig 1.) has an adherent dross attached to its lower edge and will show signs of the blue discoloration associated with the presence of surface oxidation.

Laser cutting of titanium alloys has been carried out using air or even oxygen as the laser-coaxial gas jet. The cutting speeds reported are extremely high (eg 6.4mm thick cut at 3.6 m/min with 500W) as a result of the exothermic nature of the oxidation reaction. The material is basically repeatedly ignited in the air/O_2 stream by the laser, a process which is analagous to laser-O_2 cutting of steels (refs. 1+2). Unlike steels however, the finished product requires that all the oxygen enriched embrittled edge is removed (to a depth of 3mm or more in some cases) before the base material mechanical properties can be

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Cutting and engraving of materials with a CO_2 laser

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ABSTRACT

Owing to its special characteristics, radiation of a CO_2 laser may be used as an efficient tool for processing materials. The present paper describes some possible applications which have been developed with a low power (50 W) laser for cutting and/or engraving various non-metallic materials - acrylics, cardboard, veneer, natural and synthetic leather, glass, ceramics, tc. - as well as marking of anodized aluminium. In each case operational conditions leading to best results were found experimentally, acting on parameters like laser power, processing speed, assist gas or suction.

1. INTRODUCTION

The use of lasers for material processing is ever increasing in our days. The parallel development of ancillary computerized and robotized systems which, becoming more and more complex and sophisticated, turn out highly flexible and effective, make the use of a laser as a tool increasingly attractive and profitable. From the different types of laser that find use in material processing, CO_2, Nd:YAG and excimers, the former ones have surely the most outspread applications range.

The present paper describes the results obtained with a low power laser in the processing of non-metallic materials and marking of anodized aluminium. Integration of a 50 W CO_2 laser[1] in a system with a X-Y table and a CNC[2], gave us means to evaluate the behaviour of some materials when interacting with a laser radiation of 10,6 mm wavelength. Beam guiding from the laser output to the test specimens was accomplished by a beam delivery system[3] designed specifically to this purpose.

2. CUTTING

The cutting performance of some materials during cutting with a CO_2 laser with a maximum output power of 50 W have been analysed, together with the influence of a cutting gas assist.

2.1. Acrylic plate

Laser cutting of acrylic plate is obtained by material vaporization along the interaction line. Experiments were conducted with and without an inert gas (nitrogen) assist during the cutting action.

Comparison of a set of processed test pieces, revealed that the use of nitrogen did generally yield better results: specimens cut with gas assist showed quite vertical cutting edges resulting from a vertical narrow kerf, as opposed to the skew edges obtained when the laser cut is not gas assisted and the kerf is V-shaped. This effect was most noticeable with thicker plates (5 mm and more). These results may suggest that the use of nitrogen produces a cooling of the cutting zone, thus preventing the heat, and therefore the melting process, from spreading to the sides of the cutting line. As the acrylics is inflammable, the atmosphere above the cutting zone has to be oxygen depleted, in order to prevent the material from burning - therefore an inert gas has to be used to achieve this cooling effect.

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MARBLE CUTTING BY LASER

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ABSTRACT

Through the present work on marble laser cutting, some advantages of this method over the conventional process were ascertained.

Several parameters relevant to marble laser cutting have been measured, namely the cutting speed as a function of the thickness of the marble plate and the output power of CO_2 Laser.

1 - INTRODUCTION

Interaction between a high power CO_2 laser beam with several materials has been a matter of intensive study during the last years [1 - 3].

Shock waves can be generated and supported by laser when power density is higher than 10^7 $W\ cm^{-2}$, while combustion waves are observed for power densities between 10^4 to 10^7 $W\ cm^{-2}$.

Plasma associated with combustion waves, supported by laser causes beam shielding and consequently beam attenuation. However, if the material is much reflective to CO_2 laser radiation, plasma produced on solid surface can lead to a better coupling between laser power and material surface. In fact plasma absorbs laser radiation efficiently and then reradiates with a shorter wavelength, then occasioning a better matching with surface.

Plasma behaviour in the interaction zone is then fundamental.

Material processing with industrial lasers is still very much restricted to metallurgical industry mainly the automotive and naval industries. This is so because the increased value of the product during processing is usually substantial, justifying the high capital investment of laser equipment.

Laser tecnhological applications to the treatment of rocks and other structural materials, having a much bigger capacity to absorb infrared radiation and lower thermal conductivity than metals, is proving to be not only possible, but also with a promising future.

Through the present work the feasability of marble cutting by laser radiation is stud d.

2 - THEORETICAL BACKGROUND

Laser radiation rock breakdown is based on thermal action, accelerated heating, vaporisation and transition of the material in the beam acting zone to a plasma state.

Plasma formed in this way expands within the hole left by vaporised material causing pressure against walls and than cracking the stone. This plasma and ejected debris proceeding from the area heated by laser beam absorb laser energy. To avoid beam absorption and consequent shielding, solid debris and vaporised/fused material are removed from the cutting zone with a strong air or gas jet (neutral or oxidising).

Using this method successfully requires high energy beams and beam power densities, of 10^5 to 10^6 $W\ cm^{-2}$, after focusing.

Marble is a variety of calcite and aragonite, crystalline and fine grained including impurities of quartz, chalcedony, hematite, pyrite, etc. and also some organic compounds [4].

The main component of marble is $Ca\ CO_3$ which is decomposed with temperatures between 825°C and 900°C in agreement with the primary chemical reaction

$$Ca\ CO_3 \rightleftharpoons Ca\ O + CO_2 - 42{,}52\ Kcal\ mole^{-1}$$

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TRENDS IN HEAVY SECTION LASER CUTTING

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1. Introduction

The thermal cutting with laser allows three possible cuttings, which mainly differ in the removal of the material. If the material is mainly vaporized, then this procedure is called laser sublimation cutting according DIN 2310 (German Engineering Standardization); if however the material is melted and the melted mass is removed by a gas jet, then this process is called laser melt cutting. If an exothermic chemical transformation of the material takes place , e.g. oxydation, then the process is called oxy-laser cutting.

Thermal source for all three cases is the laser beam. The cutting jet however may consist of different gases or gas mixtures. Also its form and measures as well as its speed may differ due to the cutting process. Thus it is explainable that the mechanism for the cerf formation depends on the properties of the laser beam and the cutting jet and thus leading to different final products and also to various sizes of the cerf.

2. Laser sublimation cutting

For sublimation cutting the laser beam produces a vapor channel over the whole thickness of the work piece and an inert gas jet blows out the produced vapor and - as far as existing - also the melted material. A cerf arises, when the material is moved relative to the cutting installation.

Since long extensive knowledge on the formation of a vapor channel exists taking onto account focused electron beams /1/. These ideas lead to a model and to computing programs whose results correspond to experimental results. They could be transferred very good to the laser beam, as proved in several examinations. The fundamental idea of the model consists in finding that surface, by means of an equilibrium consideration of supplied and lead away energy, on which the material reaches vaporarization temperature. Thermo-physical data of the material and the essential parameters of the laser beam are introduced into the equation. Figure 1 shows the so calculated size of the cerf for an alloyed steel. Beam data of the high power CO_2-lasers were considered. Focal position and cutting speeds were selected

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Photolithographic Masks for Integrated Optic Circuits Fabricated with an Ar⁺ Laser System

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ABSTRACT

A computer-controlled Argon laser system for writing photolithographic masks over an area as large as 50 mm x 50 mm has been developed. Different waveguide patterns have been written and some field assisted ion-exchange channel waveguides have been fabricated directly into integrated circuit mask plates.

1. INTRODUCTION

Laser beam writing systems have already been tested, proving the validity of laser sources as a photolithographic means for fabricating integrated optical devices, or masks for them, with micrometric or sub-micrometric resolution. So far, these systems have used either manually-[1,2,3] or computer-[4] controlled stages. The latter, however, required long writing times to eliminate undesired fluctuations in the positioning of the stage.

Recently, we have developed a computer-controlled photolithographic system based on an Argon laser and equipped with electronics that are both analog and digital at the same time[5]. This enables one to computer-programme perfectly straight lines between any two points arbitrarily chosen in the XY plane over an area as large as 50 mm x 50 mm and, above all, to obtain very smooth and fast displacements between them which have none of the ripples typical of digital systems.

Accordingly, masks for some typical geometries such as Y-junctions, star couplers, directional couplers and Mach-Zehnder circuits have been made whose edge roughness is so smooth that optical microscopes cannot evaluate it.

This system has an autofocus mechanism which, by means of a piezoelectric macrotranslator, controls, in real time, the reciprocal distance between the focusing optics and the mask to be patterned. Preliminary experiments with white crown glass chrome masks have been carried out, using the technique of field assisted Ag⁺ exchange[6], to make passive optical integrated circuits.

2. EXPERIMENTAL APPARATUS

Our photolithographic system consists of three main blocks: the Argon and He-Ne lasers for writing and focusing, respectively, and the optics; the XY stage with the position transducers, the macrotranslator for the autofocus and the sample-holder; the electronics for driving the system and for interfacing it with the computer.

A complete diagram of the system is shown in Fig.1. An air-cooled blue Argon laser (λ = 488.8nm) with 5mW output power on a TEM00 spot has been used. This laser splits up into two beams: one is used to monitor the power level while the other is bent by a mirror onto the focusing microscope objective. In fact, in order to obtain a very high focusing power, large aperture optics (e.g. microscope objectives) must be used. These, in turn, have a small focusing depth which gives rise to critical focusing conditions. So, an autofocus mechanism

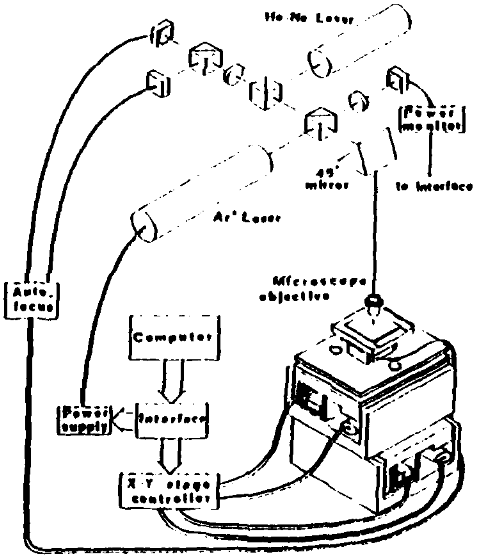

Figure 1. Diagram of the lithographic system, showing the lasers, the optics, the X-Y stage and the interconnections.

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LASER DIRECT WRITING OF GRATINGS FOR INTEGRATED OPTICS

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ABSTRACT

A novel technique for fabrication of thin-film gratings is reported. A CdS film, deposited onto an ion-exchanged glass waveguide, is photo-etched by a focussed Ar-laser beam. Computer-controlled movement of the sample allows for the formation of periodic structures, tested for input and output coupling. Some interesting effects due to the simultaneous presence of longitudinal and transverse gratings are discussed.

We also propose the technique in the realization of integrated optical devices for communications.

1. INTRODUCTION

Laser-controlled microchemical processes for deposition, etching and doping of electronic materials have become widely investigated since the early 1980s. A vast number of different technological processes has been demonstrated for various industrial and scientific applications, ranging from patterning to mask-repairing [1]. More recently, the possibility of employing photochemical-assisted laser-processes in microoptics and integrated optics has attracted novel interest with the availability of more sophisticated equipment and short-wavelength sources, such as excimer lasers [2]. In this work we report on the fabrication of gratings for integrated-optics applications by means of photo-enhanced dry-etching of CdS film with an Ar-laser source. The gratings were realized on planar optical guides, to demonstrate input and output coupling of light. The slab glass-waveguides were obtained by ion-exchanging Soda-lime glasses with Potassium ions. Cadmium Sulphide films, flash evaporated with good stoichiometry to a thickness of 1500-2000 Å, were laser-etched using an apparatus for direct-laser-writing, fabricating thin-film couplers with 1 to 2 µm periods. Experimental results are reported with the discussion of some interesting observed effects.

The technique, even if requiring some further improvements, appears to be quite promising in terms of applications to passive devices for optical communications. Typical realizable devices are input and output couplers, integrated Bragg reflectors, fiber-to-guide couplers and wavelength demultiplexers.

2. EXPERIMENTAL

In this section we describe the basic experimental procedures followed in the preparation of the final device. Due to the processes involved, each sub-section will outline the related technology.

2.1. Fabrication of planar glass waveguides

For the fabrication of slab optical waveguides, the well-known K^+-Na^+ ion-exchange technique [3] was employed with soda-lime glasses. The substrates, commercial microscope slides 1mm thick, cleaned in a diluted solution of Extran at 90°C, were preheated to 400°C and then immersed in a KNO_3 melt at the same temperature. The melt was contained in an anodized aluminium boat placed in a temperature-controlled furnace. Exchanged samples were allowed to slow cooling and then rinsed with distilled water.

The waveguides were tested by the two-prism coupling-technique using a low-power He-Ne laser source operating at 632.8nm. In agreement with the results reported by Yip et al [3], exchange-times of one hour allowed to obtain single mode (one TE and one TM) guides with an effective depth of about 2.5µm. Due to poor temperature-control, propagation losses always made the light-streak visible by out-of-plane scattering, although the in-plane scattering was quite acceptable. Best results were obtained with Corning slides.

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LASER PROCESSING

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Thermography of Laser Metal Sheet Welding

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Stainless steel cladding of structural steels by CO_2 laser welding techniques

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ABSTRACT

Steel cladding processes are usually performed in different ways: hot roll cladding, strip cladding, weld cladding, explosion forming. For the first time, a medium power (2 KW c.w.) CO_2 *laser was used to clad structural steels (Fe 37C), 3 and 5 mm thick, with austenitic* stainless steels (AISI 304 and AISI 316), 0.5 and 1.5 mm thick. The cladding technique we have developed uses the laser penetration welding process. It enables one to obtain cladded plates by making narrow weld beads, at high processing speeds (4 ÷ 10 m/min), which penetrate the structural steel substrate through a depth varyng from 2% to 20% of the cladded plate total thickness. So, mono- and bi-cladded plates have been made. Moreover, a cladding process called mono-cladded plate with "insert" was tested. In this kind of experiment, an austenitic *stainless steel plate (AISI 304 or AISI 316) or a ferritic one* (AISI430) is sandwiched between a structural steel (Fe 37C) and a stainless one (AISI 304 or AISI 316) to form a wafer-like structure. This was done to reduce to the minimum level the corrosion risks of the cladded elements, in the junction points. The influence of two different assistant gases (He and N_2) was evaluated at various processing speeds,on both mono and bi-cladded elements. Furthermore, metallographic examinations and microhardness measurements were performed on the cladded plates in order to characterize this new laser cladding technique.

1. INTRODUCTION

Steel-cladding processes are an object of growing interest for the numerous applications in all those situations that require manufactured pieces for use in aggressive means and having good mechanical resistance. In such cases, in fact, economic considerations often prevent discourage the use of structures manufactured entirely from only stainless steel. The ability to achieve notable aggregate savings, without any *inherent* loss in standards of quality or reliability, renders steel-cladding important in the construction of pressure vessels, *fixed or mobile storage tanks*, components for the chemical, petro-chemical and nuclear industries, apparatus for the de-salination of water, pre-fabricated components for the building industry etc. The principal techniques employed today for obtaining steel-cladding are essentially: hot-roll cladding, explosion cladding, strip cladding and cladding by means of plasma-filling. The results obtainable with such procedures in terms of cost, mechanical characteristics and technology,*often limit their use*. The capacity to generate an extremely high power density makes the laser interesting and particularly adaptable to *steel - cladding processes*. Compared with the other technologies employed, welding by means of a laser presents some advantages, such as no filler metal, the presence of minor distortions, very restricted heat affected zones (H.A.Z.), and above all, the possibility of achieving a high welding speed. The experimental investigation, the salient points of which are summarized in this report, has considered the use of laser welding process for the construction of mono and bi-cladded plates, and mono-cladded with "insert" plates using the following materials: AISI 304 and 316 austenitic stainless steel, AISI 430 ferritic stainless steel, *Fe 37 (weld grade C)* (AISI-SAE 1022) structural steel. There followed a complete metallurgical characterization using metallographic evaluations with macro and micrographs and then microhardness profiles of cross sections of the welds to eventually highlight the possible correlation between mechanical properties and metallurgical structure.

2. RESEARCH PROGRAMME

A research programme was established to study the results obtained from a series of tipologies of sheets cladded using the laser welding process. Particularly studied was the influence of various welding parameters using different assistant gases (He,N_2)in the manufacture of mono-cladded sheets,similar and dissimilar bi-cladded sheets and mono-cladded with insert sheets,varying the materials and thicknesses .

3. EXPERIMENTAL METHODOLOGY

The materials used in the experimentation were as follow:
- for the base material, carbon steel Fe 37, welding grade C, in thicknesses of 3 mm and 5mm;
- for the cladding materials,stainless steels AISI 304 and 316 in thicknesses of 0.5 mm,1mm and 1.5 mm ;
- for the "inserts", *stainless steels* AISI 304/316/430 with a thickness of 1 mm.

The thicknesses have been chosen to achieve a cladding of about 10 ÷ 20 % of the thickness

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Metal-Silicon Reactions with Laser Pulses

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ABSTRACT

The work done on the synthesis of metal silicides by using different pulsed lasers (ruby, Nd:glass, excimer) is presented and discussed. We found that excimer lasers offer much better characteristics for annealing of metal/silicon systems in comparison to solid state lasers.

1. INTRODUCTION

Integrated circuit technology has advanced significantly since the early years, when structures had feature sizes of 10 um and more, to the present time when devices with feature sizes of 0.8-1.0 um and junction depths of 0.1-0.2 um are produced. Nevertheless, the increasing demand for circuits with higher speed and higher component densities is leading to new circuit design and to new device structures based on innovative materials. Materials at every level of device architecture must be modified or replaced as circuit elements are decreased in size. Considerations of power loss and transmission speed are driving integrated circuit designers to lower operating voltages, where interconnect resistivity and uniformity become increasingly important.

Metal silicides are of great interest in modern integrated circuits technology to provide ohmic contacts, Schottky barriers, diffusion barriers, interconnects and so on. As metallization materials they have the advantage of being much lower in resistivity than polycrystalline silicon. Usually, metal silicides are produced by evaporation or sputter deposition of a thin metal film (typically 100 nm) on a silicon substrate (single crystal or polysilicon), followed by a heat treatment at an appropriate temperature (typically 1000 K, for 1000 s). The heat treatment is usually carried out in a vacuum furnace or in a furnace flushed with inert gas. This treatment poses some problems. In fact, the present trend in integrated circuit technology toward higher device packing density and decreased dimensions, requires low resistance thin film materials. But the used materials must present temperature properties compatible with other silicon processing operations. Near-noble and transition metal silicides are at present exstensively studied. Near-noble metal silicides form at quite low temperatures, but they can suffer phase transformations during subsequent thermal operations. In contrast, transition metal silicides are difficult to form and require annealing at very high temperature. The thermal cycle can result in significant dopant diffusion in the silicon substrate.

The main advantage of the laser annealing technique is then evident: the use of laser radiation, which deposits most of its energy near the sample surface, allows the reaction temperature for silicide

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Microstructure and Oxidation Properties of Laser Clad $Ni_{70}Al_{20}Cr_7Hf_3$ Alloys with Extended Solid Solution of Hf

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ABSTRACT

Alloys coatings for superalloys for improved higher temperature (1200°C) service life under aggressive atmospheres are of great interest at present. There is a general consensus that addition of rare earths such as *hafnium (Hf)* to these alloys has a pronounced effect on the oxidation resistance properties at high temperatures. In situ laser cladding technique was used to produce Ni-Al-Cr-Hf alloys with extended solid solution of Hf in a near stoichiometric Ni_3Al matrix. A 10 kW CW CO_2 laser was used in conjunction with a screw-feed powder dispenser to perform the in situ cladding process. Premixed alloy powder from the feeder was allowed to fall onto the substrate (Rene 80, a nickel based superalloy) at the same time and location as the laser beam in order to form the cladding. *Scanning Electron Microscope* (SEM), Transmission Electron Microscope (TEM), and *Scanning Transmission Electron Microscope* (STEM) attached with Energy Dispersive X-ray (EDX) analyzers were employed for microstructural evolution studies of alloys produced during the laser cladding process.

The microstructure of these alloys mainly consist of *dendritic cell of* γ'_p which is of the Ni_3Al type with about 11-14 wt% Hf and an interdendritic eutectic phase. Aluminum in the Ni_3Al was found to be partially replaced by Cr and Hf. Although there were some subtle differences in the cell spacing, composition and other minor features between the samples *depending on the process parameters*, no radical differences were observed. Based on the observations made, the possible phase transformation sequence of this group of laser clad Ni-Al-Cr-Hf are suggested below.

$$\text{Liquid(L)} \rightarrow \gamma'_p + L \rightarrow \gamma'_p + E \rightarrow \gamma'_p + (\gamma'_E + \delta_E)$$

where γ'_p is *primary* γ' *phase* with ordered f.c.c. structure ($L1_2$), γ'_E is eutectic γ' phase with ordered f.c.c. structure, and δ_E is the other eutectic phase with heavily faulted f.c.c. structure. E represents the eutectic phase.

The eutectic phase is a mixture of two phases, one Hf rich and the other Hf lean. Dark field microscopy in the dendritic zones reveals ordered domains and the morphology of the domains depends on the process parameters used during laser cladding. Convergent beam electron diffraction and x-ray spectroscopy have been applied to characterize the phases formed during the cladding process. Initial Differential Thermal Analysis (DTA) work indicates that the γ' dissolution temperature for the claddings is at least as high as the substrate material (Rene 80) if not higher.

In order to evaluate the oxidation response of the claddings with respect to the substrate material, thermogravimetric analysis (TGA) was carried out in a TGA unit. Single cycle oxidation tests of eight hours at [illegible]00°C in slow flowing air reveal that the claddings have a lower weight gain rate than the substrate itself. Microchemistry and microstructure of the oxidized samples are examined using SEM attached with EDX and Auger Electron Spectroscopic (AES) techniques. The oxide scale in this system is primarily Al_2O_3 and the improvement in the oxidation *resistance* is believed to be at least partially due to the formation of mechanical pegs of hafnia, which hold the alumina on to the substrate and prevent oxide spallation.

Theoretical *modeling of diffusion* was also carried out to estimate the extent of the extended solid solution in laser cladding. By incorporating a nonequilibrium partition coefficient for dilute solution the model was used to determine nonequilibrium *phase diagram for* Ni-Hf and Ni-Al systems. The theoretical prediction compares well with experimental data.

I. INTRODUCTION

Alloys for coatings for gas turbines require superior *mechanical properties* and oxidation resistance at elevated temperatures (1200°C) and aggressive environments. In recent years attention has been focussed on developing suitable high temperature oxidation resistant protective coatings for nickel or cobalt base superalloys for enhanced service lifetime. M-Cr-Al-RE (M = Ni, Co, Fe and RE = rare earth) systems are widely used for such coatings. These coatings, when obtained using the right proportion of the elements tend to form Al_2O_3 rich scales. Al_2O_3 is the coating of choice because of its limited volatility, sluggish growth kinetics, relatively inert behavior and also because oxygen diffusion through the oxide scale is also extremely small.

Behavior of Austemfered Ductile Irons (ADI) Subjected to Laser Surface Melting

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Laser surface engineering of tool materials

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ABSTRACT

The very nature of laser surface melting allows for localised modification of a surface, and it is this feature which makes it ideally suited to treatment of single point cutting tools. High speed steel M42 material has been laser surface melted and in trials, the resulting microstructural modifications have produced improved cutting performances over conventionally heat-treated material. In addition, laser alloying of a low-alloy steel substrate to achieve an M42-type cutting tip has also demonstrated acceptable cutting performances. With the different wear conditions encountered in die materials, it is thought that the addition of ceramic material to the die may enhance performance, and preliminary work on surface melting and alloying of this type of substrate is also reported.

1. INTRODUCTION

Tool steels, particularly high speed steels used in cutting (M-type) and cold work die steels (D-type), normally contain large carbides resulting from the initial casting process. The role of these primary carbides in wear situations is a matter for some conjecture, but they do contain a large amount of alloying elements which would otherwise be available for solution during austenitising, and their presence is known to reduce toughness.

In order to minimise this embrittling effect, various techniques are used to redistribute or avoid these large carbides[1,2]. Conventionally, tool steels undergo hot working to change the segregated, as-cast structure to one containing a homogeneous distribution of primary carbides[2-4]. More recent developments include thermally sprayed, rapidly solidified powders[2,5-7] and the development of lower alloy, matrix tool steels with the added economic benefit of less stategic alloy usage.

The use of high power continuous wave CO_2 lasers to surface melt tool materials provides two possible advantages. Firstly, a superheated melt pool results in dissolution of the primary carbides, and the subsequent solidification of a much refined structure without primary carbides. Secondly, the inherent features of laser surface melting mean that the cooling rate during solidification borders the 'rapid solidification' regime, introducing the possibility of extended solid solubilities. Work on splat quenching of M42[8] has resulted in a significant modification of secondary hardening characteristics, reported data showing an increase in the maximum hardness achieved and the tempering temperature at which the peak occurred.

Melting the substrate also allows the possibility of changing the chemical composition of the surface via laser surface alloying. This process provides two routes to follow. Firstly, a surface of M42 composition may be created by laser surface alloying of a low alloy steel substrate, allowing substantial savings of strategic alloying elements in the bulk. Secondly, the addition of alloying elements to a tool steel substrate for enhanced mechanical properties. This modification may result from either the creation of a hard phase as a solidification product, or by providing additional material to contribute to secondary hardening. Wear tests of surface alloyed D3 materials simulating cold forging are underway.

2. EXPERIMENTAL PROCEDURE

2.1 Material

The compositions of the two alloys used are given in Table 1. M42 is a high performance, high hardness high speed steel used generally in the cutting of ultra high strength steels and nimonic alloys. D3 is a much less expensive, high chromium, high carbon, cold work die steel, widely used in extrusion dies and punches for forming of a wide range of engineering materials.

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ALUMINIUM REFLECTANCE UNDER EXCIMER LASER IRRADIATION

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ITALY

ABSTRACT

The reflectance of cold rolled Aluminium during Xe-Cl excimer laser pulse irradiation with power densities in the range 10 MW/cm² to 14 GW/cm² as been investigated. Plasma formation at 500 MW/cm² without previous melting at lower power is observed.

"Laser cleaning" of the surface lowers plasma theshold to the pure Aluminium value and melting of the metal is detected as well between 60 and 110 MW/cm².

INTRODUCTION

Material processing by laser light is the most attractive application in material science of fundamental studies concerning light matter interaction [1]. Since laser technology has become reliable and available at relatively low cost, industries have started to employ lasers for non-reactive processing, in the sense that no new compounds are present with final product.

Today the most common lasers for operations on an industrial scale are the CO_2 lasers principally because of the low operating cost and the high energy convertion

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NEW CORROSION RESISTANT CERAMIC COATINGS BY LASER PROCESSING

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ABSTRACT

Fabrication of thick oxide ceramic coatings upon a metal substrate by laser processing has been investigated. Crucial parameters studied included beam power, diameter, overlap and traverse speed, feed powder size and coating environment. Coatings were characterised by a range of surface analytical techniques. The corrosion protection afforded by a coating was assessed in both oxidising and sulphidising environments.

1. INTRODUCTION

The corrosion protection of high temperature alloys used in industrial environments usually relies on the formation of a Cr_2O_3 or Al_2O_3 surface layer. This protection can be undermined by the diffusion of constituents of either the alloy or the environment along grain boundaries or other short circuit diffusion paths in the oxide, causing scale failure, including spallation. One possible way to improve the situation is to apply an amorphous ceramic coating to the alloy which, because it has no grain boundaries, provides a better diffusion barrier than the naturally-formed oxides. The effectiveness of this approach has been demonstrated as thin ($\leq$ 20 μm) amorphous silica coatings, applied by vapour deposition procedures, greatly improved the oxidation behaviour of a 20%Cr/25%Ni/Nb stabilised stainless steel (1) and the oxidation, sulphidation and carburization resistance of Incoloy 800H (2). Amorphous ceramic coatings, therefore, could have immense potential in providing corrosion protection in a range of technologies. Unfortunately for many applications geometrical considerations prevent the use of the existing chemical (CVD) and plasma assisted (PAVD) vapour deposition processes. Consequently, there is a need to develop an additional, versatile, coating procedure without these constraints which ideally would be similar to plasma spraying that unfortunately cannot be used with silica.

BENNETT.

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Laser surface treatment of AISI 420 tool steel

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ABSTRACT

Samples of a martensitic stainless steel containing 0.47%C and 12.8%Cr were surface melted using continuous wave CO_2 laser radiation and a multiple pass technique. The structure of the laser modified layer was studied by optical microscopy, scanning electron microscopy and X ray diffraction.

The melted zone presents a narrow region near the fusion line with a ferritic-martensitic structure, that seems to have solidified by an almost partitionless mechanism. It is followed by a cellular-dendritic structure in the center of the melted trail, that consists on δ-ferrite, martensite and $M_{23}C_6$ carbide. The absence of austenite is surprising: it can be explained by the tempering effects of the solidification structure, due to subsequent laser passes.

1. INTRODUCTION

Laser melting is an excellent method for producing rapidly solidified surface layers in a controlled and reproducible way. A large range of cooling rates can be produced by this technique, depending on the laser type and working mode, on the processing parameters and on material properties. As a result of fast cooling, very interesting non equilibrium structures are produced, which are characterized by the fine scale of their morphological features, as well as by the presence of supersaturated metastable phases.

When applied to tool steels, laser melting yields a thin melted layer (0.05 to 0.5 mm). As a result of its solidification, a columnar structure grows epitaxially on the substrate, which can contain martensite and substantial amounts of retained δ ferrite and austenite, depending on the chemical composition of the steel as well as on the surface treatment conditions[1-5]. Since these surface layers have improved wear, erosion and corrosion resistance characteristics, numerous investigations are beeing carried out on this subject.

AISI 420 is a medium carbon, inoxydable martensitic tool steel that finds widespread use both in the plastic moulding industry and for the fabrication of cutting tools by virtue of having a good compromise between hardness, toughness, wear and corrosion resistance. In this paper, we describe preliminary results of an investigation on laser surface treatment of AISI 420 steel, which aims to evaluate laser treatments for the improvement of wear and corrosion properties of plastic moulding materials.

2. EXPERIMENTAL METHOD

Commercially available AISI 420 steel was used in the present study. Its chemical composition is given in Table I.

Table I. Chemical composition of the steel

Element	C	Cr	Mn	Mo	Ni	Si	P	S
Wt.%	0.47	12.82	0.77	0.26	0.19	0.40	0.024	0.011

The steel was supplied in square section bars of 20 x 20 mm. Specimens of 50 x 15 x 10 were cutted from the bars and the surfaces to be treated were rectified and ground with metallographic paper of 280 grit. To avoid contamination, no coatings were applied to decrease reflectivity.

Melting was carried out with a 4kW CO_2 laser in the CW mode, with a lens of 127 mm of focal lenght. The specimens were mounted on a CNC positioning table and submitted to multiple-pass scanning under argon protection. The surface treating conditions were varied in the ranges indicated in Table II.

Table II. Laser surface melting conditions

Laser power	$580<P<2020$ W
Translational speed of the table	$3.3<V<13.3$ mm/s
Specimen distance to focus	$6<d<10$ mm

After melting, the specimens were sectioned and observed by optical microscopy, scanning electron microscopy and X ray diffraction. Specimens for microstructural studies were prepared by mechanical polishing followed by etching in one of Villela's or Murakami's reagents. The topography of the as-solidified surface was observed by scanning electron microscopy without any prior preparation.

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Laser welding of thin sheet of AISI 301 stainless steel

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ABSTRACT

Preliminary results of an investigation on laser welding of AISI 301 stainless steel thin sheet are presented. Welds were made with a CO_2 continuous wave laser, varying power density and welding speed. The welds were studied by optical and electron scanning microscopy, X-ray diffraction and hardness tests. Experimental results show that under appropriate conditions, sound welds are obtained, with a negligeable heat affected zone and a fine microstructure in the fusion zone. The fusion zone shows a cellular - dendritic microstructure, with austenite and ferrite as the major constituents. Ferrite, whose content is 5 to 7%, is predominantly intradendritic with both vermicular and acicular morphologies. However some interdendritic ferrite may also be present. The characteristics of the structure suggest that the solidification mode of AISI 301 stainless steel is essentially ferritic.

1. INTRODUCTION

Austenitic stainless steels are monophasic after annealing or water quenching due to the supression of the $\gamma \to \alpha$ transformation, that results from the addition of nickel and chromium to iron. On the contrary, after welding, the microstructure of the as welded metal is dual phase, with an amount of ferrite that, for conventional welding processes, can be predicted from the chemical composition of the weld metal, by empirical diagrams, like those proposed by Schaeffler[1] and DeLong[2]. For welding procedures that produce fast cooling rates (like laser and electron beam welding), the cooling rate is also important on determining the structure[3]. Since a certain amount of ferrite in the weld metal prevents hot cracking and affects strength and corrosion resistance[4-7], optimization of the weld properties is achieved by controlling the proportion of δ ferrite and, to a certain extent, its morphology.

A detailed understanding of the correlation between the microstructure of the weld metal, its composition and its thermal history is far from accomplished[8-11]. Suutala and coll.[8,12-15] suggested that three different solidification modes can occur in AISI series 300 austenitic and austenitic-ferritic stainless steels welded by shielded metal and gas tungsten arc processes. The solidification mode depends essentially on the balance between α and γ stabilizing elements, expressed by the ratio Cr_{eq}/Ni_{eq}. Cr_{eq} and Ni_{eq} being calculated by DeLong equations[16]:

- for $Cr_{eq}/Ni_{eq} \leq 1.48$, austenite is the first phase to grow and ferrite, if any, is formed by an eutectic reaction[12]. These phases do not suffer any transformation during cooling and are kept in the metaestable condition at room temperature. This type of structure was classified as type A by the authors.
- for $Cr_{eq}/Ni_{eq} \geq 1.95$, the first phase to solidify is ferrite and austenite, if any, is formed by a solid state transformation[13]. Ferrite presents an acicular (or lathy) morfology and its content is greater than 12%.
- for $1.48 < Cr_{eq}/Ni_{eq} < 1.95$, intermediate structures (type B) are observed, that have features in common with microstructures of type A and C[14]. For those compositions, ferrite is the first phase to solidify; austenite forms from the melt at the intermediate spaces, by a peritectic or an eutectic reaction, depending on the composition of the alloy, or results from a solid state transformation.

Besides, the authors considered that the influence of the solidification mode was negligeable compared with the influence of the chemical composition[15].

David[17] proposed a different classification of the ferrite morphology. He identified four distinct types of ferrite that were designated by vermicular, lacy, acicular and globular. The first three types correlate with different solidification modes; on the contrary, globular ferrite appears in the solid state, due to spheroidization and coallescence of other morphologies. Besides, David et al.[18,3] showed that the high cooling rates produced by laser and electron beam welding affect the solidification mode, favouring austenitic solidification or suppressing $\alpha \to \gamma$ transformation. To synthetize these results, David et al.[3] proposed a modified Schaeffler diagram, which includes the influence of cooling rate on the microstructure.

AISI 301 stainless steel is extensively used in the construction of railroad wagons

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Characterization of real laser beam profiles with few parameters for metallurgical applications

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ABSTRACT

In first approximation the material induced effects after laser beam interaction are function of the whole transmitted energy and of the local "irradiance" (in $W.cm^{-2}$) levels and gradients. Consequently 3 informations may be able to describe this beam : carried power, shape and dimensions in the interaction zone. Thus shape and dimensions of a real beam would be simply and universaly described. If we are interested by the induced effects in the straight of the beam axis, 3 parameters are sufficient to describe the beam : the incident power P, an equivalent radius r^*, and an axial "spread" factor of energy distribution g(E). These parameters have been mathematically defined but they are also experimentally measurable (in particular from transmitted power through a small aperture or a slit localised in the vicinity of the work zone). The experimental characterization of a 4 kW c.w. CO_2 laser (CILAS CI 4000) has been carried out for several powers (between 200 W and 3 kW). When the power increases it has been find that r^* increases and g(E) stays nearly constant in spite of mode evolution. Presently the real-time evaluation of these parameters is investigating. Moreover these 3 parameters can be directly introduced in simplified analytical tridimensional thermal model, and so the behaviour expectation and the working parameters fluctuations effects (for example "mode" changes) become easier. At last this approach may be able to carry out "objective" comparison between the various high power lasers in different laboratories.

1. INTRODUCTION

To optimize a laser heat treatment or modelize the laser beam effects, the metallurgist must answer the following questions : How can a real high-power laser beam be described ? What is its shape ? What are its dimensions ?

An ideal shape (gaussian, or "top-hat") is not realistic in general case and the complete profile (if it is known, what is unusual) is difficult to introduce in modelization (in particular this is impossible in an analytical modelization).

The definition of a laser beam "radius" is also a delicate problem. Even if the beam profile is an ideal gaussian profile, the "radius" can be defined by several ways : $r_{(1/e)}$, $r_{(1/e^2)}$ or $r_{(1/e^3)}$ and eventually $r_{(h/2)}$ at half height . This is function of authors, process of radius evaluation, and utilization of this parameter, [illegible] the chosen definition is not always given. For an actual laser beam the $(1/e^2)$ radius definitions have none physical significations and two beams with the same "radius" and the same carried power can induce very different effects after interaction with material (this is also true for a gaussian beam with a same $r_{(1/e^2)}$ but more or less diaphragmed).

So, it seems necessary to characterize the real laser beam with few parameters. These parameters will have a physical signification, an "universal" character and they will be simply measurable.

2. DEFINITION OF PARAMETERS ABLE TO CHARACTERIZE A LASER BEAM

The chosen parameters must describe the profile the simpliest and the most completely that is possible. Also, they must be able to go back to the characteristic parameters of laser-material interaction. This interaction is essentially governed by : the whole carried energy (that conditions the "volume" of induced microstructural transformations, i.e. the extent of the transformation), the local levels and gradients of energy density : "fluence" (they condition the local "intensity" of the induced microstructural transformations, i.e. the local nature of this transformation). Usually the metallurgist is interested by the induced effects in the vicinity of the laser beam axis and the maximum fluence of the beam is near of this axis. Consequently the description can be simplified and 3 parameters will may be able to characterize the beam with sufficient accuracy : the whole carried power P, an "equivalent radius" r^* and an axial "spread" factor g(E), which will be evaluated in the interaction plane.

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Energy distribution analysis of high power laser beam from spots on paper

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ABSTRACT

When a laser beam radiates an isolant material like paper during a small period of time (<0,1s), the induced degradation can be considered proportional to the incident energy density ("fluence"). This phenomenon can be used to vizualise the laser beam profile before or after crossing an optic device. The beam mode , its possible fluctuations, and the interference phenomena introduced by optic elements can be easily evidenciated (it is only necessary that fluence be included between 1 and 20 J/cm^2). In a quantitative viewpoint the observed degradations (level of coloration, burn) can be standardized in fluence. So for a given interaction time it is possible to define the local density power ("irradiance" in W/cm^2), necessary to induce the observed degradation. Consequently it is possible to reconstitute the energy repartition profile of the beam; this was achieved for the case of c.w. CO_2 laser of 4 kW for different powers. This procedure requires a good quality paper (type "printer inkjet paper") and the accuracy can be ameliorated utilizing a "printer thermal paper". An image analysis software allowing the deduction of the intrinsic characteristics of the beam is being studied.

1. INTRODUCTION

There are different methods to determine the energy repartition profile of a laser beam (see in particular [1] where a complete review was achieved). At present the methods type detectors arrays or beam scanning are prefered to those based on the principle of "photographic plates". In this last case the flux of the incident energy density is evaluated by the "blackening" of a photographic plate. We propose a method presenting similarities with this photographic method but still easier and cheaper to achieve.

In fact we know (see [2] in particular) that if we radiate an insulating material like paper during a time sufficiently small to neglect the thermal diffusion (< 0,1 s in practice), the induced degradations (yellowy-burn) may be considered proportional to the local incident energy density ("fluence" in J/cm^2). This phenomenon can be utilised to visualize the energy distribution profile of the beam.

2. QUALITATIVE STUDIES THAT CAN BE ACHIEVED FROM LASER IMPACTS ON PAPER

To do this it is necessary to dispose of a good quality paper (homogeneous texture with thin grains) type writing paper and it is also necessary to can pulse or chop the beam to have an interaction time τ modulable between 10^{-3} and 10^{-1}s. So, for a given electric power and dimension of the beam it is easy to adjuste the interaction time that conducts to degradations which evidence the energy repartition of the beam in a particular plane and in a given instant.

By this way we can determine the evoluton of the energy repartition along the beam trajectory for different emission powers (see fig. 1). Consequently it is possible to determine the position of the beam waist or the point of focalisation after passing through an optic system.

In a given plane we can also try to show up the fluctuations of the emission mode for a given operating condition of the laser source (see fig. 2). To realize this, the beam must be chopped ($\tau, \Delta\tau$) and the paper must be moved with a speed v.

Further it is possible and easy to evidence the defects introduced by an optic device. For example a dust on a lens induces an absorption of radiation and a diffraction phenomenon which can be observed. We can also accede to the fine structure of the energy repartition for example after crossing an homogeneisation device (type kaleidoscope 10 x 10 mm in the case of fig. 3a). The fine array of diffraction (interfringe = 0,12 mm, fig. 3b) shows up that the resolution of the method is of about some tens of micrometers.

These various experiments are related at length in 3.

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Behavior of Austemperad Decctiles Irons (ADI) subjected to Laser Surface Melting

Jones

Fagosga

Liceaga

Jasnowski

(Manuscript Due)

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MEASUREMENT AND PREDICTION OF SURFACE TEMPERATURE IN RELATION TO LASER SURFACE HARDENING OF METALS

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ABSTRACT

When the surface of the material is heated above the critical temperature with a laser beam, metallurgical changes occur in the surface region of the material. As the laser beam passes, quenching of the heated surface by the underlying mass of cold metal can produce a transformation hardening depending on the cooling rate. Therefore, the prediction and the measurement of cooling rate in surface hardening is essential.

To determine the cooling rate experimentally, the surface temperatures of laser heated workpieces were measured using fast response thermocouples while the surface temperature distribution was predicted theoretically for four different workpiece materials.

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New type of modulator for intense CO_2 laser radiation and its applications

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ABSTRACT

This paper reports on a new type of modulator which can be used for many applications of intense CO_2 laser radiation. The modulator is based on the principle of the Fabry-Perot interferometer and acts as a beam splitter with variable reflectivity which is placed outside the laser cavity. By means of the tuning of the spacing between the two plane parallel interferometer plates the intensity of the transmitted as well as the reflected part of the incident laser beam can be modulated. The principle of construction, typical properties and some characteristic applications are given.

1. INTRODUCTION

Many applications of CO_2 lasers require pulsed radiation or a well-defined fast modulation of the laser light. Examples are laser cutting, welding and heat treatment of various materials, uses in the electronics and microelectronics industry, e.g. cutting and scribing of ceramic and other materials which are susceptible to thermal fracture, furthermore drilling, engraving and marking, etc.

In recent years the laser-material interaction was investigated in detail, e.g. the basic physics of laserbeam absorption, the plasma generation leading to "enhanced coupling" and the influence of heat input and thermal conductivity on the processing. All of these processes depend on the temporal behaviour of the laser radiation and therefore the well-defined modulation of intense laser light has an increasing importance, especially with respect to laser materials processing of high precision and the investigation of dynamic phenomena in this field. A typical example is the process dynamics of laser cutting. Although laser cutting is obviously a continuous process, dynamic phenomena play a most important role especially related to cut quality. To achieve optimum conditions in the basic research of these processes as well as their industrial applications, the development of modulation techniques for intense CO_2 laser radiation with a high variability of all modulation parameters is of great interest.

This paper reports on a new type of modulator for intense CO_2 laser radiation which operates outside and independent on the laser cavity. Its principle of operation renders possible remarkable properties and certain advantages in comparison to the modulation of the laser gas discharge.

2. PRINCIPLE OF OPERATION

The principle of operation of the modulator is based on the fast tuning of a Fabry-Perot interferometer (FPI).[1] A FPI splits the incident laser light into a transmitted and a reflected part, i.e. the modulator acts as a beam splitter with variable reflectivity R_{FPI}. The FPI is formed by two plates of transparent material both with AR-coatings on the outer side and the reflectivity R on the inner side. Assuming negligible losses in these plates and perpendicular incidence of a plane wave, the transmission T of the FPI can be written

$$T(d) = \frac{P_T}{P_o} = \frac{(1 - R)^2}{1 + R^2 - 2R \cos(4\pi\frac{d}{\lambda})} \qquad (1)$$

where P_o is the incident single-frequency light power, P_T the transmitted light power, λ the wavelength of light and d the spacing of the FPI. Fig. 1. illustrates the dependence of T on the tuning of the spacing Δd, the so-called "Airy-function", for $\lambda = 10.6\ \mu m$ and two reflectivities R = 0.3 and R = 0.5 which are suitable for most applications. The curves show, that the FPI is tuned from maximum (T_{max}) to minimum (T_{min}) transmission by $\Delta d = \lambda/4$. With $T_{max} = 1$ and T_{min} from Eq. 1 the contrast K_T of the system is determined by

$$K_T = T_{max}/\,T_{min} = \frac{(1 + R)^2}{(1 - R)^2} \qquad (2)$$

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LASER TECHNOLOGIES IN INDUSTRY

SPIE Volume 952

LASER PROCESSING

L.C.V.D.

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Application of L.C.V.D.: Metallurgic,

Micro-Electronics and Micro-Optics

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(Manuscript Due)

Paper given at the SPIE Conference on "Laser Technologies in Industry" hold in Porto, June 88

Laser-induced Formation of SiO_2-Layers for Microelectronics

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Abstract

After a short overview about the different techniques of the SiO_2-formation by photo-induced methods used in microelectronics, the laser-induced deposition of SiO_2-layers on silicon wafers from TEOS by ArF excimer laser are depicted in more detail and the deposition conditions are outlined in dependence of substrate temperature, partial pressure and laser fluences. The physical properties of the SiO_2-layers were investigated by FT-IR spectroscopy and ellipsometry; the electrical properties of CV-characteristic, mobile ion density, interface state density and breakdown voltage are given.

1. Introduction

In the conventional semiconductor processing of IC's chemical vapor deposition techniques (CVD) for producing dielectric thin films are mainly based on thermal or plasma-induced deposition systems. As silicon wafer dimension increase and devices features decrease, there is an enhenced need to perform device fabrication at reduced temperatures or reduced time-temperature cycling and to process thin dielectric films free of radiation damage to the devices. Normally high temperature processing results in higher quality dielectric films but simultaneously high temperature processing can cause a number of deleterious effects, like crystal defect generation, uncontrolled dopant diffusion, large film stresses including wafer warpage, which may inhibit pattern transfer of subsequent photolithographic steps.
The photo-induced deposition through its temporal and spatial selectivity of energy distribution opens new techniques and methods in thin dielectric film processing for IC's. It can avoid most of the above mentioned drawbacks of conventional thermal or plasma-induced deposition techniques. Especially the possibility of a laser-induced deposition technique for direct structured deposition or surface modification by a specific reaction would allow to simplify some process sequences in the IC technology, so that the expected availability of such new methods will have a great impact to the conventional IC technology.

2. Photo-induced formation of SiO_2-layers

In order to depict shortly in this context some most important photo-induced techniques to produce SiO_2 layers also the so called rapid thermal processing methods are mentioned. Table 1 shows different modes or pathes for sheet formation of SiO_2 especially for the silicon technology. A review of the commonly used oxidation techniques are given by Katz /1/. In the case of photo-induced oxidation of a silicon wafer the radiation is absorped by silicon and the wafer is heated to the desired reaction temperature; simultaneously an photo-induced enhancement of the oxidation rate additionally to the thermal induced reaction occur. The results of these investigations are revieved by Boyd /2/. It is known that interstitial or substitutional oxygen atoms in the silicon crystal may precipited to SiO_2 if the concentrations exceed limit of 10^{17} O-atoms/cm^3). By high energy implantation of O-Atoms (200 keV) with a sufficient high dosis (2 10^{18} O/cm^2) a buried SiO_2-layer ($\approx$ 0,3 µm) is formed after annealing. Here rapid optical annealing (1300-1400°C) is applied to generate a stoichiometric SiO_2-layer /3/. Besides other techniques like crystallization of thin poly-Si layer this so called SIMOX-method (Seperation by IMplantation of OXygen) is very promising for future SOI microelectronic devices.
For purposes of planarising structured surfaces of IC's the formation of a SiO_2-layer from a Si-O polymer layer can be established. The Si-O polymers are brought onto the substrate by a "spin-on" technique and are cured in order to evaporate the solvent and polymerise the material /4/. It is possible to structure these films by ablation before curing /5/. This so called Spin-on-Glasses (SOG) achieve some importance for multilevel metallization techniques, especially because of the planarizing effect during the spin-on procedure. Formation of SiO_2 layers is also possible by the reaction of a SiO film in air or O_2 under the influence of 193 nm photons /2/.

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Progress in laser chemical vapor deposition of silicon thin-films

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ABSTRACT

Laser Chemical Vapor Deposition (LCVD) has been attracting a considerable amount of interest to deposit thin-films for microelectronics structures. In this paper we will discuss the progress obtained from a series of experiments of several laser-based methods, taking in to particular consideration only the Silicon deposition. Depending on the gas and kind of laser used different kinetics can be selectively induced leading to distinct film-morphologies and diverse growth parameters. LCVD processes also offers the capabilities of reduced temperature processing and mask-less patterning for sub-micron resolution. Further investigations are needed to explore the wide potential of LCVD applications.

1. INTRODUCTION

The current trend in microelectronics technology is to use extensively dry processing techniques and reduced temperatures to obtain reliable sub-micron devices. In this direction, different methods of thermal and photo-induced reactions has attracted interest to investigation. The lasers became to be experimented as new tool for microelectronic's processing due their unique characteristics as source of monochromatic photons with high power and elevated spatial resolution. It was demonstrated that the laser irradiation can be used to induce chemical reactions leading the deposition of thin films with particular growth modes and morphologies. This method became called Laser CVD (LCVD). Films of metals, oxides, silicides and semiconductors have been successfully grown by this technique on to various types of substrates. Due to the great number of Laser-induced reactions that have been investigated the discussion of LCVD must be a lengthy article. Therefore our paper in this conference will review only the progress in the LCVD of Silicon. We believe that this material is a good example because it can be deposited by different LCVD techniques. Also, since Silicon is the most commonly used semiconductor material its properties are well known, and so this knowledge can help us to put forth some useful perspectives to be explored. A more wide paper covering a classification of the basic LCVD methods and its use in the deposition of different materials will be published elsewhere[1].

2. LASER CVD PROCESSES

The LCVD processes are a classe of Laser-induced or enhanced gas-surface reactions. An outstanding importance of LCVD over conventional or Plasma CVD is the availability of different kinds of selectivities that can be easily achieved in order to drive the deposition reaction by a particular route or to produce films with different properties. The Laser excitation can be either directly by gas phase, by adsorbates or by the surface of the substrate. Depending on this energy path the deposition can occur by simple photolysis, by simple pyrolysis or by a combination of them. So in some processes the thermal energy can be insignificant and the films can be grown even on substrates kept at room temperature, which is a remarkable achievement.

The laser excitation of the gas-adsorbate-substrate system depends strongly on the photon energy. So the laser wavelength can be choose to selectively excite the desired phase. Since the lasers can be tuned with a very narrow bandwidth, the quantum excitation can be derived only to the desired reagent, even if there is several reagents in the same phase. This selectivity can be sufficiently high to permit up to isotope distinction. For the microelectronic processes, this selectivity can help to prevent the contamination of the deposit by impurities from gases that eventually can be present in the system.

The ability of the laser radiation to propagate in low divergence beams permit irradiate the photons to the surface of the substrates at different angles. This can be very useful to select the phase to be excited. For instance, if it is better to excite the adsorbate layer, it will be good to use an impinging beam parallel to the surface or at a low angle direction.

Other very important property of the laser beam is the high spatial resolution that can be easily attained. With a simple lens system it is possible to focus the beam with a spot comparable to the wavelength. Therefore, it is natural to concentrate the incident energy with micron to sub-micron scale region. This ability can localize the deposition reactions and them produce features in the substrate without the use of the conventional photolitho-

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Laser Excited Vapor Systhesis of Submicron Powders from Halogenated Silanes

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(Manuscript Due)

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Laser Interferometer for Optical Testing using Nonlinear Optical Effect

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ABSTRACT

The interaction of light from a relatively medium power CW laser with a nonlinear medium, such as nematic liquid crystals, has been used to devise an interferometer for measuring aberrations of the incident beam. The reorientation of anisotropic molecules of the medium contributes to the induced refractive index change Δn that is usually a strong nonlinear function of $|E|^2$. The associated self-focussing and diffraction effects produce a spherical beam which is used as the reference wave. The operation of this common-path interferometer can be described by taking analogy with a point-diffraction interferometer.

1. INTRODUCTION

We describe the theory and operation of a laser interferometer using optical-field induced refractive index changes in a nonlinear material such as liquid crystals. On propagation through the medium, the laser beam, having a suitably oriented direction of polarization, undergoes modulations that have been utilized constructively in the design of an interferometer for optical testing. When the laser intensity is adjusted just above the threshold, only the paraxial part of the beam is capable of interacting and getting modulated. It provides the reference beam that interferes with the unmodulated test beam to produce fringes of equal optical thickness. The reference and the test waves are mutually concentric and collinear. The interferometer falls in the category of common-path interferometers and bears a close resemblance to a point diffraction interferometer.

The purpose of this paper is to describe in detail the salient features of the interferometer.[1] After recapitulating the reorientational behaviour of nematic liquid crystals when subjected to an external field, we will discuss the principle and operation of the interferometer. Experimental results are given for specific applications and will be discussed by taking into consideration various interferometer parameters.

2. REORIENTATIONAL BEHAVIOUR OF LIQUID CRYSTALS

The interaction of a light beam with a nonlinear medium to produce changes in its refractive index is a well known topic.[2] The action of the medium on the propagating beam, known as the self focussing effect, represents one of the most intensely investigated nonlinear phenomena. In recent years, a number of materials have been discovered that exhibit an extremely large optically induced birefringence. One example of such materials is nematic liquid crystals that have a birefringence of $\Delta n \sim 0.2$. Herman and Serinko[3] have presented an extensive study of the nonlinear processes in relation to the weak beam amplification and production of diffracted beams. Earlier studies relate to measuring the electronic and orientational contributions to nonlinear susceptibilities and obtaining relaxation rates and transport properties associated with the orientational motions of individual molecules.[4-7] The nonlinear dependence of the material refractive index produces a modulation on the propagation of the light wave responsible for the self focussing effect. The non-uniformity of the field, in the transverse cross-section of the illuminating beam, causes a radial dependence of the refractive index pattern and it may be accompanied by an asymmetry caused by the elastic constants of the material. The observation of a laser induced system of ring structure in OCB (Octyl-Cyano-Biphenyl) liquid crystals was first reported by Zolot'ko et al.[8] and it has been further investigated by several other authors.[9,10] This ring structure is caused by the nonlinear aberrations of the material and similar diffraction structures have previously been reported in other nonlinear media.[11]

The molecular reorientation under the influence of intense light waves is caused by their interaction with the optical electric field and is similar to the classical Freedericksz transition.[12] This effect relates to deformations undergone by a thin nematic liquid crystal (NLC) film under the influence of an external electric (or magnetic) field. The effect is observed by the change in the optic axis (director) of liquid crystals and it can be described by using the continuum theory.[13] The orientation of the sample optic axis with respect to the electric field depends upon the dielectric

Modern Optical Coating Technologies for Low-Loss Dielectric Films

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ABSTRACT

Highest quality dielectric films are required today for various optical applications. Many inorganic compounds which were difficult to deposit by conventional techniques in form of well adherent, dense, hard, and stable low-loss films are now routinly synthesized by reactive gas discharge plasma and energetic ion and/or coating material atom processes. A survey over such PVD coating technologies and the resulting film properties is given in this paper.

1. INTRODUCTION

Metal oxide coatings for high quality interference optical applications and for planar optical waveguides must exhibit excellent performance. The following requirements are stringent: Low film absorption values, film refractive indices close to bulk values and independent on film thickness, dense homogeneous microstructures with smooth film surfaces and interfaces to reduce light scattering and to secure firm film characteristics under varying conditions of humidity and temperature, high adhesion, hardness and abrasion resistance, high environmental stability.

Many chemical compounds, however, decompose during evaporation and sputtering. The highly volatile reactive components, such as oxygen, disappear rapidly in the pumping system and the compound films formed on the substrates are therefore often non-stoichiometric in composition. Thus, for instance, direct evaporation as well as direct sputtering of Al_2O_3 results in oxygen deficient films [1] and the same occurs with TiO_2 and other compounds. To overcome this difficulty, Auwärter [2] and Brinsmaid [3] suggested that the deposition be carried out in the presence of oxygen or generally, depending on the compound processed, of some other desired reactive gases. Meanwhile reactive deposition has developed into a powerful technology.

The factors responsible for the efficiency of a reaction are numerous and very complex. They include at least the chemical nature of the reacting species, the stability of the reaction gas or compound species, the free energy of formation of the compound, its dissociation pressure and dissociation energy, the substrate temperature, the condensation behaviour of the reactants on the substrate, sometimes influenced by the substrate temperature, the partial pressure of the reactants, and so on. The reaction probability on collisions between the reactants can be enhanced by activating one or even both of them [2,4,5]. This means that it is an advantage both for the occurence and also for the yield of a reaction when the reactants are ionized, dissociated or in electronically excited states. Activation can be performed by substrate heating, uv radiation, electron impact, or in the presence of a gas discharge plasma.

In more recent developments considerable attention has been paid to techniques for improving beside stoichiometry also all the other desired film properties mentioned above. These techniques avoid high substrate temperatures and supply the required energy to achieve proper optical, chemical and mechanical film characteristics by the use of high energy coating material atoms and working or reactive gas species. Adding the proper amount of energy directly to the growing film by energetic ion processes appears to be beneficial. Ion-assisted reactive evaporation is therefore a very effective technology, along with various reactive sputtering variants and reactive ion plating. The use of plasma brings these and other quite different and independent coating technologies closer together.

2. REACTIVE AND ACTIVATED REACTIVE EVAPORATION

The properties of thin films deposited on various substrates by conventional evaporation and condensation under vacuum are generally found to be different from those of the corresponding bulk materials.

The loss of oxygen that usually occurs during evaporation of many oxides may cause optical absorption in the films. The effect could be appreciably corrected in the reactive deposition process [2] by adding oxygen to the residual gas. For all that,

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Design of MESFET optical amplifier

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ABSTRACT

GaAs MESFETs, originally designed for microwave applications, have become an important component of receivers in high-speed optical telecommunication systems. For these applications, the crucial point in the device modeling is the evaluation of the induced gate noise and its correlation to the channel noise.

In this paper the design of a low-noise small signal optical amplifier using GaAs MESFET is carried out.

The principal noise sources of GaAs MESFETs are analyzed in order to completely characterize the equivalent model. Particularly channel-noise represents the dominant effect in the determination of the optical receiver sensitivity.

Total input noise current of the optical amplifier, due to correlated gate and drain MESFET noise, has been estimated in order to evaluate the excess channel-noise factor Γ for different values of photodiode capacitance. This procedure allowed to choose the photodiode with minimum noise.

At last, scattering parameters, minimum noise gain, gain-frequency dependence and bandwidth of the amplifier have been evaluated in the frequency range of interest.

1. INTRODUCTION

GaAs MESFET devices have become important components in high speed lightwave receivers [1]. For these applications, the crucial pointin the device modeling is the evaluation of the induced gate noise and its correlation to the channel noise.

In this paper the principal noise sources of GaAs MESFETs are analyzed in order to completely characterize the equivalent model [2][3][4][5]. Channel noise represents the dominant effect in the determination of the optical receiver sensitivity [6].

The total input noise current in the optical amplifier, due to correlated gate and drain noise has been estimated in order to evaluate the excess channel-noise factor Γ for various photodiode capacitances.

At last, a low-noise small signal amplifier, operating in the S and X frequency bands, has been designed. Scattering parameters, minimum noise gain, gain-frequency dependence and bandwidth of the amplifier have been evaluated.

2. SMALL-SIGNAL NOISE EQUIVALENT CIRCUIT.

An equivalent circuit of the MESFET device, which includes noise sources, is shown in Fig.1.

At high frequencies, the principal intrinsic noise sources are related to the thermal noise in the channel and in the gate. They are expressed respectively by the following equations [7]:

$$\langle i^2_{nd} \rangle = 4kT\Delta f g_{mo} P \qquad (1)$$

$$\langle i^2_{ng} \rangle = 4kT\Delta f \frac{\omega^2 C^2_{gs}}{g_{mo}} R \qquad (2)$$

where $\langle\ \rangle$ indicates the mean square value, k is the Boltzmann constant, T is the absolute temperature, Δf is the bandwidth, g_{mo} is the transconductance, $\omega = 2\pi f$ is the angular frequency, C_{gs} is the gate-to-source capacitance, and P and R are quantities which depend on the bias and geometry of the device.

In Fig.1 are also reported the resistor thermal noise sources, expressed by:

$$\langle i^2_{n_i} \rangle = 4kT\Delta f/R_i \qquad (3)$$

where i is for g_i, g_s, s, o or dr.

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ION BEAM PROCESSING OF MULTILAYER SEMICONDUCTOR STRUCTURES

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ABSTRACT

The redistribution of implanted ions within GaAs/AlAs multilayer structures due to post-implantation furnace annealing is reported in this paper. The structures were grown by molecular beam epitaxy on GaAs [illegible]ates and implanted with either hydrogen or beryllium ions. After furnace annealing at temperatures to 700 C, these samples were examined using secondary ion mass spectrometry. The measurements show that the hydrogen and the beryllium atoms redistribute with post-implantation annealing and that both species accumulate at the buffer layer/substrate interface. The concentration of atoms at this interface can exceed 1E19/cm-3 and may be related to the crystal imperfections arising during the inital stages of epitaxy. The significant redistribution of implanted ions may also alter the optoelectronics properties of multilayer semiconductor structures processed in this manner for laser applications.

1. INTRODUCTION

Ion beam modification of GaAs/AlGaAs multilayer structures is an important semiconductor processing technique for optoelectronics. This technique has been useful in various stages of laser fabrication including electrical insulation, surface passivation, material layer mixing, and electronic doping [1,2]. However, the use of ion beams also introduces crystal damage and foreign atoms which may change the optical and electronic properties of the semiconductor material. Since these effects can interfere with device performance, it is important to understand the behavior of implanted ions in potential device structures.

In the present study we have investigated the behavior of hydrogen 1H and beryllium 9Be ions implanted into GaAs/AlAs superlattices which were later subjected to post-implantation annealing. These ions were chosen since hydrogen is active in passivation of dopants in GaAs [3] and beryllium is a widely used p-type dopant. The implanted ions as well as the constituent Al atoms have been depth profiled using secondary ion mass spectrometry (SIMS). The SIMS profiles show that post-implantation annealing leads to a ma[illegible] redistribution of the implanted ions and that the redistributed ions tend to accumulate at the [illegible]ffer layer/substrate interface.

2. SUPERLATTICE STRUCTURES

Both of the superlattices used in this study consisted of alternating layers of GaAs and AlAs grown by molecular beam epitaxy (MBE). The first one, designated A, was grown at North Carolina State University at a temperature of 620 C on an undoped, semi-insulating, [100] oriented, LEC GaAs substrate. The total thickness of this superlattice was approximately 6 um with the individual layers being 7.3 nm for GaAs and 4.0 nm for AlAs. A GaAs buffer layer approximately 60 nm thick separated the substrate from the superlattice. All these layers were Sn doped to a level of about 1E16/cm3. From these thicknesses, the average aluminum concentration of this superlattice was estimated as being 0.354. Other details relating to the growth of superlattice A and the characterization of the layer parameters have been previously reported [4].

The second superlattice, designated B, was grown at a temperature of 648 C at the Naval Research Laboratory on an undoped, semi-insulating, [100] oriented, LEC GaAs substrate. The thickness of this superlattice was approximately 0.63 um with the individual layers being 5 nm for GaAs and 10 nm for AlAs. A cap layer of GaAs about 60 nm thick was grown on top of the superlattice. Each of these layers was Si doped to a level of about 1E16/cm3. A buffer layer of undoped GaAs approximately 250 nm thick separated the substrate from the superlattice. The average aluminum concentration of this superlattice was estimated as being 0.666.

3. HYDROGEN IMPLANTS

Superlattice A was implanted at room temperature with 300 keV 1H ions to a fluence of 1E16/cm2. The

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Feedback Induced Non-monotonic Behavior of Differential Quantum Efficiency with the Current in Inga ASP Injection Lasers

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(Manuscript Due)

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Calculation of the Ambipolar Diffusion Coefficient through lasing action in gases.

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ABSTRACT

A new method to find the ion density of a gas at any time after the discharge is described. In this method the overvoltage of a fast discharge in a gas or its lasing action can be used. That is to say, knowing the experimental values of the actual starting voltage of a pulsed gas discharge or the laser output and comparing them with the relevant theoretical values, the ion density can be found. The result of this procedure is the calculation of the ion density at a time after the discharge equal to the inverse of the high voltage pulse repetition rate. Thus, by changing this pulse repetition rate the temporal behaviour of the ion density is found.

An application to the N_2 gas leads to the calculation of the ambipolar diffusion coefficient, the value of which is in sufficient agreement with the one in the literature.

1. INTRODUCTION

The research on the ion decay processes after a pulsed discharge in a gas is always important. This is because it finally leads to the comprehension of the ion behaviour and to the estimation of the coefficients of different ion decay processes. For example, such laboratory research on the gases existing in the ionosphere contribute to the understanding of the ionosphere properties.

In the afterglow of a gas discharge two main ion decay processes take place: the diffusion and the recombination. Being of a collisional microscopic nature, the recombination is a considerably more complicated mechanism in its details than the diffusion and it depends on the relative kinetic energies of the electrons and ions and, more importantly, of how energy and momentum can be conserved in the recombination process.

To examine these fundamental processes occuring in gas discharge the continuity equation for ion density is used. If the only ion decay process is the diffusion, then the continuity equation for ions is given by the relation.

$$\frac{\partial n}{\partial t} = D_\alpha \nabla^2 n \qquad (1)$$

where n is the ion density and D_α is the ambipolar diffusion coefficient. To simplify, we can assume a fundamental diffusion mode with a decay time τ and rewrite

$$\frac{\partial n}{\partial t} = -\frac{n}{\tau} \qquad (2)$$

where τ is the diffusion decay time. Its solution is given by the equation

$$n = n_o e^{-t/\tau} \qquad (3)$$

If the electron temperature is equal to the ion temperature (T_e=T_+), then the decay time can be related to other quantities as follows;

$$\frac{\Lambda^2}{\tau} = D_\alpha = 2D_+ = \mu_+ \frac{2KT}{e} \qquad (4)$$

where Λ is the characteristic diffusion length. This depends on the geometry and the container dimensions. For rectangular geometry of the diffusion space we have

$$\frac{1}{\Lambda^2} = \left(\frac{\pi}{L_1}\right)^2 + \left(\frac{\pi}{L_2}\right)^2 + \left(\frac{\pi}{L_3}\right)^2$$

D_+ is the positive ion diffusion coefficient, μ_+ is the positive ion mobility, e is the electronic charge, K is Boltzman's constant and T is the gas temperature. Thus, when only one type of positive ion is present in the afterglow, its mobility can be determined by a measurement of the time constant to the ion loss rate.

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BARA

Off axis elliptical zone plate for nonsymmetric Fourier transforming

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ABSTRACT

An off axis elliptical zone plate (EZP) together with refractive optics has been used for obtaining the 2-D nonsymmetric Fourier transform (NFT) of a given object with parallel beam illumination. The NFT thus obtained is exact, excepting a linear phase factor due to the carrier spatial frequency used in the EZP recording. Experimental results show the ability of this system for separating quasi-unidimensional spectra of slightly different orientation.

1. INTRODUCTION

In the last years, interest for NFT systems working with parallel or spherical beam illumination has grown. Unlike the usual symmetric Fourier transformers, NFT systems redistribute the information at the Fourier plane in a nonsymmetrical way, giving rise to an unequal scaling of the u- and v-axes in the frequency domain. NFT systems are rotationally variant, performing a controlled deformation of the object spectrum. This fact is useful for many applications, in particular for obtaining superresolution in one direction[1] allowing to increase the angular discrimination between quasi-unidimensional spectra angularly very close[2] and to detect with greater sensitivity small misalignments in object orientation[3].

Until now, NFT systems were designed making use of conventional refractive elements (cylindrical lenses), being the design flexibility limited by the availability of well corrected refractive phase transformers with proper characteristics. The use of a thin holographic optical element such as an off-axis elliptical zone plate allows to make easier this design, also reducing the number of required components.

2. NFT SYSTEM

The proposed NFT system is shown in fig. 1, being a modified version of the developed by Szoplik et al . The EZP transmittance function is given by:

$$t(x_4,y_4) = \sum_n a_n\, \psi(x_4, nF_x)\, \psi(y_4 + (1/nF_y)\sin\alpha,\ nF_y) \qquad (1)$$

where a_n is the diffracted amplitude coefficient corresponding to the n th diffracted order of the EZP, $\psi(a,c) = \exp(i\pi c a^2/\lambda)$ and F_x and F_y are the two inverse focal distances corresponding to the two ortogonal primary focii of the EZP.

The object is located at the X_1Y_1 plane, a distance $f_x = 1/F_x$ form the EZP wich performs the Fourier transform along the X-active direction in the X_7Y_7 plane. The pair

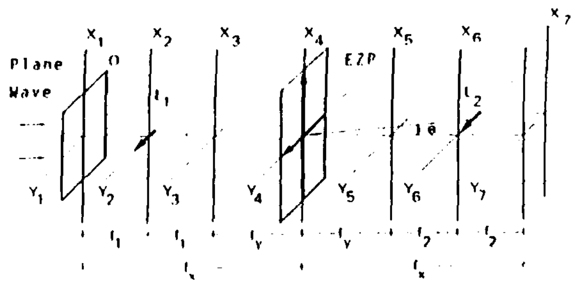

Figure 1. NFT system
The arrows indicate the active direction of each element.

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Spinodd Determination in Polymer Oligomer Mixture in Solution

C.C. Cesteros

(Manuscript Due)

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Rapid determination of the Wobbe index of natural gas

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ABSTRACT

A fast response Wobbe meter for natural gas is described. The working principle of the Wobbe meter is based on a relationship between the Wobbe index, the concentration carbon dioxide and nitrogen and the specific density of natural gas. The concentrations are determined by Raman spectroscopy.

A HeNe laser serves as the light source which generates Raman scatter in a cuvette filled with natural gas. A part of the scattered light is picked up and passed by two fibre optic cables to detection equipment. Filters are used to the allow N_2 Raman light respectively CO_2 Raman light to pass. The power of the light passing the filters is determined by photomultipliers. The concentrations are calculated from the power of the Raman light signals, the pressure and temperature of the gas flowing through the cuvette, the laser power and callibration data. The accuracy of the concentration meters is better than 0.25% (gas = 100%). This figure can be attributed to the statistical fluctuations of the intensity of the Raman light and to the way of estimating the background of the light signals. The response time is only 8 seconds. The accuracy of the Wobbe meter is better than 0.25 MJ/m^3 which is good enough for a control instrument.

1. INTRODUCTION

The burning properties of a natural gas are characterized by the Wobbe index. The Wobbe index of a gas is defined as:

$$W = H/\sqrt{d} \qquad (1)$$

where: W - Wobbe index (MJ/m^3)
H - caloric value per unit volume (MJ/m^3)
d - specific density of the gas (-)

For reasons I shall not go into here, fast Wobbe meters are needed in gas stations to control the blending of natural gases with different Wobbe indexes.
A new Wobbe meter has been designed on the principle that the Wobbe index of natural gas can be determined from the concentrations of N_2 and CO_2, and the specific density of the gas.[1] Unfortunately, there are no suitable N_2 concentration meters for natural gas on the market.
In the designed Wobbe index meter the N_2 concentration is measured by Raman spectroscopy.[2] Since it was possible to integrate the carbon dioxide concentration meter with the nitrogen concentration meter by means of a relatively small quantity of extra instrumentation, this was done as part of the overall development of the Wobbe index meter.

In this paper I will describe the outcome of the development, including the laboratory evaluation and field trials of the laboratory model of the Wobbe index meter.

2. MEASUREMENT PRINCIPLE OF THE CONCENTRATION METERS

In general, the power of scattered Raman light by a component when a volume is illuminated with laser light, depends among other factors on the laser power and on the number of molecules of the component in the illuminated volume. So the following formula applies for a gas:

$$K_i = C_i \times I_i \times T/(p \times L) \qquad (2)$$

where: K_i - concentration of component i (-)
C_i - constant specific to component i ($bar \times K^{-1}$)
I_i - power of the Raman light scatter by component i (W)
T - absolute temperature (K)
p - pressure of the gas (bar)
L - power of the laser beam (W)

The concentration meters in this paper are based on determination of the concentrations from the power of the component specific Raman light, the gas pressure and temperature, and the laser power. The constant C_i (formula 2) is given by a calibration.

Interaction parameters of Polymer-Polymer Systems by Laser Light Scattering

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N. Gonzalez

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(Manuscript Due)

All-Optical Wide-Area Remote Sensing of Dispersal of Unsafety

Humio Inaba

(Manuscript Due)

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In-Situ measurement of ammonia with a $^{13}CO_2$-waveguidelaser system

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ABSTRACT

A laser gas monitoring system has been developed to measure in-situ concentrations of gaseous pollutants (in our case ammonia) at various temperatures. The heart of the system is a tunable $^{13}CO_2$-waveguide laser. By varying the resonator length the laser is frequency modulated between two neighboring emission lines. One line is absorbed by the species investigated, while the other is used as a reference. By this referencing the system is autocalibrated continously. The high spectral resolution of the laser method supresses interference by other species. Fast evaluation of the digitalized signal shortens the measurement time to less than one minute. The lasers high output power is used in a multiple path arrangement, which allows the detection of ammonia concentrations in the one vppm range. First results of measurements in a power plant are reported.

1. INTRODUCTION

The measurement of ammonia concentrations in industrial environments has become of increasing interest in recent years. To this end, a promising infrared laser technique exists in differential laser absorption. This technique uses a laser that works alternately at 2 wavelengths, with different absorbances for NH_3. Since both the $^{12}C^{16}O_2$ and $^{13}C^{16}O_2$ laser wavelengths fall within the ν_2 band of ammonia, several coincidences between these wavelengths and absorption minima or maxima can be found.

For quantitative detection it is necessary to know the absorption coefficients at the precise wavelength of the particular laser lines used. Measurements of the coefficients for dilute NH_3-air mixtures with $^{12}C^{16}O_2$ [1] and $^{13}C^{16}O_2$ lasers have been reported with regard to their use in monitoring ambient concentrations [2]. Recently, a method of obtaining two wavelengths alternately generated in a cw CO_2 waveguide laser has been proposed [3] and used to control atmospheric pollution. For detection of NH_3, it was found most promising to work with a $^{13}CO_2$ laser.

In this paper we want to introduce an in situ ammonia monitoring system, which is based on a commercially available $^{13}CO_2$ laser. This system is robust enough to work even in rough industrial environments. Since the temperature dependence of the NH_3 absorption is known, it is possible to measure also in gases at evaluated temperatures.

2. THEORY

The determination of species concentration by differential absorption techniques is based on the Lambert-Beer law

$$I(\nu) = I_0(\nu)\exp(-\alpha(\nu)\,c\,l) \tag{1}$$

which relates the incident and transmitted intensities $I_0(\nu)$, $I(\nu)$ to the absorption coefficient $\alpha(\nu)$ at frequency ν, the concentration c and the measurement path length l. Letting ν_1, ν_2 denote the laser emission lines coinciding with NH_3 absorption maximum and minimum, respectively, the absorption coefficient can be written

$$\alpha(\nu_1) = \alpha_1 + \alpha_{NH_3} \tag{2}$$

$$\alpha(\nu_2) = \alpha_1 \tag{3}$$

Here α_1 includes all background diminution of the probing beam due to reflection losses, scattering at smoke particles etc. and can be taken as a constant, if ν_1 and ν_2 are close together. α_{NH_3} is the NH_3 absorption at ν_1, while the NH_3 absorption at ν_2 has been assumed to be negligible. The ratio of the transmitted intensities

$$\frac{I(\nu_1)}{I(\nu_2)} = \frac{I_0(\nu_1)}{I_0(\nu_2)}\exp(-\alpha_{NH_3}\,c\,l) \tag{4}$$

still depends on the ratio of the initial intensitites, which can easily be determined in a reference beam and detector. If $I^R(\nu_1)$, $I^R(\nu_2)$ denote the intensities at the reference

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OPTICAL PROCESSING OF MILITARY TARGETS

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Abstract

We tried several optical processing methods in order to improve the quality of military images for commanding purposes: spatial filtering in a 4f system with coherent illumination, pseudocolour encoding of spatial frequencies, matched filtering. Cryptography by means of a double aberrating medium was also found to be successful. Additionally we improved the method of Yu, Ti and Zhang for the determination of the ...

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OPTICAL IMPLEMENTATION OF THE HOPFIELD MODEL USING A SPATIAL LIGHT MODULATOR DISCUSSION OF PROPERTIES AND PERFORMANCE

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In this paper we propose an optical design for implementation of neuronic Hopfield network. We describe the algorithm and its potential possibilities as associative (or content addressable) memory. We then describe the optical set (using a magneto-optic spatial light modulator) and explaning its operating mode: The binary transparency of the SLM does not allow a direct and accurate experimental realisation of the theoretical algorithm. However, there is a particular setup that can implemented it powerfully but with a reduction of the effective number of neurons. The operating speed is then evaluated from the characteristics of the SLM "Sight-Mod" manufactured by SEMETEX corp.: the maximun operating frequency seems limited by the speed of the optical valve.

I. INTRODUCTION

Neural networks based on the Hopfield model are convenient ways to store information in an associative memory [1]. Such memories can be distinguished from traditional memories by two essential characteristics:

- The information is not stored in specific loca-

$$T_{ij} = \sum_{\mu=1}^{p} (2\xi_i^{\mu} - 1)(2\xi_j^{\mu} - 1) \quad ; \quad T_{ij} = 0. \qquad (1)$$

2) an application phase allows access to learnt patterns by providing the network with their partial description. This step is governed by an *evolution* rule which defines the new state of a neuron from the

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A Laser Induced Fluorescence Immunoassay System for the Detection of Salmonella and E. Coli

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Abstract

Total internal reflection fluorescent immunoassay techniques provide a powerful method of detecting biological antigens. A laser system has been developed to record the evanescent wave excited fluorescence emitted from the dye labeled polyclonal antibodies developed for Salmonella spp. and E. Coli 0157:H7. A cw argon laser tuned at 488 nm was used to induce the emitted fluorescence at about 520 nm. Measurement of the fluorescence was performed via an optical multichannel analyzer, on-line to a microcomputer. Antigen samples of varying concentrations were analyzed to test the operation of the system. A description of the laser detector is presented in this paper.

I. Introduction

This research involves the development of a fluorescent dye linked immunosorbent assay for the identification and quantification of Salmonella spp. and Escherichia coli 0157:H7. This essay is analogous to commerically available enzyme linked immunosorbent assays (ELISA's) for Salmonella. The two types of assays differ in the detection mechanism, and ELISA's detection is based upon an enzyme mediated colorimetric change of a reagent solution, whereas the fluorescent assay's detection is based upon fluorescent intensity values observed. This fluorescence is due to fluorescein isothiocyanate (FITC) labeled antibodies which in turn specifically bind to Salmonella or E. coli antigens. Bound FITC antibodies were detected using a modification of Kronick and Little's (1975) procedure for fluorescence excitation by total internally reflected light. In the experimental optical arrangement used, the fluorescence was excited by the evanescent field of 488 nm argon ion laser light undergoing total internal reflection at the surface on which the immunological reagents had been adsorbed, and was detected using an intensified optical multichannel analyzer on line to a microcomputer for data display and analysis.

II. Total Internal Reflection

Total internal reflection (TIR) can take place at any material interface where the second propagation medium has a lower index of refraction than the first. The angle at which TIR starts, known as the critical angle, is given by (AXELROD, BURGHARDT and THOMPSON, 1984),

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Lasers Systems for Bio-Medical Applications

Vera Russo

(Manuscript Due)

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Holographic investigation of different types of surgical fixing devices

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Abstract

The method of double-exposure holographic interferometry was applied to study the behavior of lower leg bones supported with different fixing devices. The torsion and bending was examined for both types of fixators: an external one (Orthofix type 10000) and an internal one (*osteosynthesis AO plate, Howmedica*). The influence of the fixation on the mechanical response to the external load of the supported tibial shaft is discussed. The advantages of holographic interferometry in the above investigation are pointed out.

Introduction

From the various capabilities of holography for image processing <1> <2> and measuring purposes, mainly holographic interferometric techniques <3> have found more extended application in biological and medical research.

Especially, holographic interferometry as a technique allowing a non-destructive testing and high-resolving deformation analysis of whole objects, has gained popularity over the recent years in biomechanics <4> or experimental surgery <5>. As shown in <4>, holographic interferometry is capable of providing unique data and can be succesfully used for comparative testing in experimental orthopaedics. Results of further holographic investigation on the deformation of human tibial bones under static loading are presented in this paper.

Material and methods

For the investigation described here samples of tibio-fibular complexes were taken from adult human cadavers between the fourth and the sixth decade of life. The shanks were striped completely of soft tissues except for the interosseous membrane. The bones were fixed at the lower end by means of dental acrylate to a heavy metal plate to ensure maximal stabilization of the object. The bones with a transverse midshaft osteotomy, *supported* by a fixing device, were examined. The bending and torsion forces were applied to the upper end of the tibia. The deformation was measured in anterior-posterior direction The strength in this direction is greater then in the medial-lateral direction <6> This can be also shown by *holographic interferometry* <7>.

To realize the torsion loading the metal pin was mounted to the upper end of the tibia perpendicular to the direction of applied force. In this way, by changing the point of application of force to the *pins between* two holographic exposures, the bending and torsion could be realized simultaneously.

The deformations w of tibial samples result from differential loads Δ F, ranging from 0.4 to 1 N, after applying preloading *force F in the range* of 20 to 50 N. The following experiments were carried out: bending and torsion of the tibia supported with internal fixation plate in the case of osteotomized tibia and fibula intact. Then, the fibula was also cut transversally and these experiments are repeated. In the same way the external *fixator* was tested. Recently, the role of dynamization for fracture healing is pointed out <8> <9>, therefore, the experiment was carried out with the fixator telescop locked (static mode) and unlocked (dynamic mode). This enables the comparison between

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HOLOGRAPHIC ENDOSCOPY

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Abstract

The introduction of holographic metrology into endoscopy is the decisive step towards a metrological basis for a quantitative diagnostic within body cavities, with the advantages of holographic interferometry such as large focal depth imaging, non-destructive, non-contactive, and high-resolving analysis of structure, form, deformation and vibration of the object under study. There are two possibilities of holographic endoscopic recording: at the distal end within the instrument or with an external holographic camera. In both cases optical fibers can be used for easy handling and flexibility.

Introduction

Although today endoscopy has established its place in medical diagnostics, it has not yet exceeded the function of a qualitative, subjective observation method. Yet, modern diagnostic techniques increasingly require an objective, quantitative determination of form, structure and (micro-)movement of the object under study.

Optical techniques, which can meet these requirements, are those of laser holographic interferometry known from industrial non-destructive testing.

For endoscopic inspection purposes this opens - besides others - the following possibilities:

o quantitative determination of micro-movements of the (endoscopic) object, which are not detectable by mere visual inspection;
o quantitative analysis of the local elasticity of the object area under study;
o analysis of structure changes even underneath the (endoscopically) visible object surface by holographic measurement of local elasticity differences.

In principal, there are two approaches in developing a holographic endoscope:

o the hologram can be recorded inside the instrument or
o by using an external recording device - a holographic camera.

Holographic recording inside the endoscopic instrument

Recording a hologram inside the endoscopic device requires a small holographic set-up to be inserted into the tip of the instrument. The advantages of this arrangement are full three dimensionality of the reconstructed image with a large focal depth as well as maintaining of parallax. In this case a large aperture is achieved, since here the entrance pupil corresponds to the hologram area. This results in low speckle noise. Drawbacks are a large outer diameter of the endoscope needle (typically in the order of centimeters) and the necessity to develop a complete new type of endoscope.

The first holographic endoscope of this kind was developed by Hadbawnik [1] in 1976. He discussed the problem to guide and generate a defined and reproducable reference beam, which is necessary especially for holographic metrology. The usual spatial filter arrangement would be difficult to adjust inside the endoscopic instrument. Thus, a single mode fiber was used for laser light delivery to a beam splitter, which separated object and reference beam. Hadbawnik claimed that no (Q-switched) pulsed lasers can be used in such an arrangement,

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New devices for controlling the interaction of high-power laser light with anorganic and organic materials

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ABSTRACT

Two unconventional methods, which may be used in some cases to control heat conduction conditions responsible for secondary effects both in laser surgery and in laser material transformation, are presented. The tools developed for this purpose are based either on thermoelectrically controlled (TEC) or on thermodynamically controlled (TDC) temperature pattern generation around the acting laser beam. Using TEC laser scalpel secondary tissue damages may be avoided, while transformation hardening by laser radiation may be controlled through the thermodynamic effect known as Ranque-effect.

1. INTRODUCTION

High power lasers are becoming increasingly important tools in two areas of everyday life: in medical field, as a replacement of mechanical and/or electrical scalpel, and in engineering, as a noncontact method for material transformation. Their major role as an alternative or adjacent to existing methods is to alter, excise or remove material considered to be excessive.

Although the exact physical mechanism responsible for these effects is in most cases not entirely understood, there is no doubt that heat generated by the absorption of laser radiation plays an important role even in cases such as laser driven chemical reactions. The large absorption coefficient at a given wavelength assures the deposition of most of the energy in a rather small volume, thereby inducing a rapid temperature increase and resulting in high temperature gradient pointing from the surface not only into the underlaying material layers, but also in all directions on the material surface itself, thereby promoting the conduction of heat from the illuminated material layer to unexposed areas. This conducted heat may have an effect on the goal one wants to achieve by using intense laser radiation not only by depriving thermal energy from the area the property of which is to be altered, but also by varying the temperature of the nonilluminated area.

It can be shown[1] that if h is a distance from the point of attack P of the laser beam on the surface of question, the local temperature T_o will rise here as

$$T - T_o = (Q/4\pi Kh)\ \mathrm{erfc}\ (R) \tag{1}$$

where $R = h/2(k\tau)^{1/2}$, and the thermal conductivity K is related to the thermal diffusivity k as

$$k = K/\rho c_m \tag{2}$$

and Q is the thermal energy resulting from the absorption of the laser radiation at point P. The erfc (R) is an error function which is ~ 1 if R is small, and with the increase of R it decreases monotonously to 0.

Thus, the result of the interaction of intense laser radiation with matter in the vicinity of the point of laser attack strongly depends upon conditions of the energy transport through heat conduction which, however, could be influenced by the functions $\Delta t/\Delta s$ and $\Delta h/\Delta t$ where $\Delta t = T - T_o$, and Δs the time interval in which the temperature change takes place.

We present in this paper therefore two methods which may be used in some cases to control the heat conduction conditions and, thereby, the 3-D temperature distribution in the vicinity of the impact point of the intense laser radiation.

In our reasoning until now we have made no distinction in the character of the material the laser light is acting upon, since the basic laws for laser-induced thermal effects are the same for both living and nonliving material, i.e., for biological tissue and engineering materials: the only difference is that the boundary conditions are not the same. This, however, means that tools that can be used in laser surgery to control some of the damaging heat effects may be practically the same, from engineering point of view, as those utilized to control laser material transformations. Therefore, we describe one of the methods sug-

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WORKSHOPS

WORKSHOP

LASERS IN MEDICINE

Fifty people around have participated in the workshop "Lasers in Medicine": most of them participants on the previous days on the conference "Laser Technologies in Industry", also some invited physicians and others interested in the topic from various University Departments.

The discussion concentrated mainly on the state-of-the-art of laser applications in Medicine, the definition of strategies for its growth and future trends.

It was recognized the actual importance of the routine laser medical applications in developed countries, namely in Europe, in specialties such as laryngology, gastroenterology, gynecology, pneumology, urology, dermatology, oftalmology and others. Applications still at the research and development stages in neurology, vascular cardiology and tumor treatments have been considered to have a great possibility of success. The implementation of applications with no established scientific principles was considered to be undesirable and harmful for the credibility of the applications already proved as useful and beneficial.

The european trend for the development of laser applications in Medicine appears organized in the so called "EEC concerted action" where five european countries (France, U.K., Germany, Holland and Italy) are already represented. The aim of this organization, supported by EEC, is to define priority areas of research and development, organize workshops and conferences and encourage the exchange of personel between institutions of different countries. Within this framework, short courses and visits to medical laser centers in Europe may be easily arranged. Priority areas have been already established: tumor treatment and vascular cardiology;the development and research of diagnosis techniques may also been considered.

Because of the interdisciplinary nature of the laser medical applications, some specific difficulties may prevent a stronger development. Teams working in routine applications or in research and development projects should include physicians and physicists or laser engineers. Communication problems caused by different education and professional interests have been pointed out as the main difficulties to organize strong and efficient teams. Those teams and other well organized groups, although with different degrees of integration, should be the agents to spread the well established techniques, develop new ones and have responsibilities on the education of young physicians, physicists and laser engineers.

It was stressed the importance of technical and basic scientific education of physicians in modern times. Laser courses, where the fundamentals and limitations are clearly taught, should be included in curricula of graduate studies in the specialties where lasers are or can be important. A sound education on basic sciences as Mathematics and Physics should be maintained at undergraduate level.

With this strategy, a new atmosphere in the medical community, already threatened by underemployment,

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WORKSHOP

LASERS in OCEAN SCIENCES

REPORT ON WORKSHOP MEETING

LASERS IN OCEAN SCIENCE

by

S.P. Almeida

A workshop meeting on Lasers in Ocean Sciences was held on June 9, 1988 the day after the conference on Laser Technologies in Industry in Porto, Portugal, June 6-8, 1988.

The goals for this workshop meeting included the following:

1. Provide a forum for the exchange of ideas on the role of *lasers in ocean sciences.*
2. Identify current problems in ocean sciences which are of interest to the European community.
3. Determine if sufficient interest exists to pursue a (future) topical workshop on lasers in ocean science.
4. Determine which areas to focus on.
5. Determine if sufficient interest exists among the European communities to contemplate a multi-national research effort to solve ocean science problems via the application of lasers.

Most if not all of these goals were realized as a consequence of this *workshop meeting.*

The world's *oceans* are of vital importance to mankind in the role they play in our *ecosystem.* They affect weather and atmosphere, both as a solar energy reflector and storage of energy. Photosynthesis by oceanic phytoplankton is one of the important processes which helps maintain a proper oxygen balance in the atmosphere. Phytoplankton also form a fundamental link in the basic food chain which exists in the ocean. An unbalance in the oceans' natural process in providing for its sea life could have a deleterious effect on our ecosystem. Man's persistent contamination of the oceans with oil spills, raw sewage, poisonous chemicals in liquid and solid form are a serious threat to all nations. The currents, tides and winds will sooner or later bring home consequences of these actions.

The workshop was well attended and a very good exchange of ideas took place. Participants at the meeting represented a broad cross section of the European community not to mention the inclusion of persons from the United States and Eastern Bloc countries.

The suggestions for possible areas of lasers in ocean science can be divided into two broad categories: Surface and Underwater research.

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